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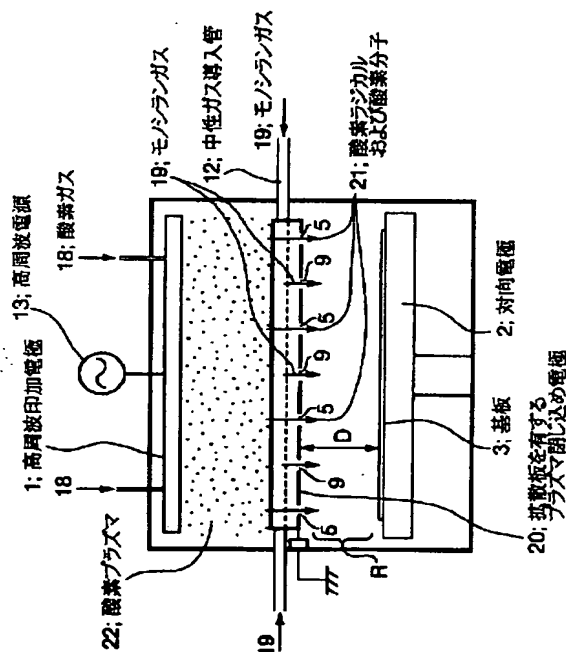
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(54)【発明の名称】 プラズマCVD装置およびプラズマCVD成膜法

(57)【要約】

【課題】 気相化学反応を用いて成膜を行うリモートプラズマCVDにおいて、気相化学反応の過剰進行抑制と均一膜形成を両立させる。提供する。

【解決手段】 酸素ガス18を高周波印加電極1に供給し、酸素ラジカル及び酸素分子21を、酸素プラズマ22外の基板処理領域Rで導入されるモノシランガス19と反応させ、基板3表面に成膜を行うリモートプラズマCVDにおいて、モノシランガス19を基板処理領域Rに導入する導入孔が配置されたプラズマ閉じ込め電極20と、基板3(被堆積基板)の垂直方向の距離が、基板処理領域Rにおける成膜時平均自由行程λgの1500倍以下となっており、かつ前記プラズマ閉じ込め電極20は、中空構造であってモノシランガス19(中性ガ)を板内で均一化するためのガス拡散板(第1のガス拡散板及び第2のガス拡散板)が設けられている。



【特許請求の範囲】

【請求項1】 被堆積基板が設置される基板処理領域と、第1のガスのプラズマを形成するプラズマ生成領域と、前記基板処理領域とプラズマ生成領域とを分離して前記第1のガスのプラズマを閉じ込め、第1のガスの前記プラズマから中性ラジカルを含む第1のガスを通過させる孔が配置されたプラズマ閉じ込め電極板を有するプラズマCVD装置であって、

前記プラズマ閉じ込め電極板が中空構造であり、内部に第2のガスをこのプラズマ閉じ込め電極板内で均一化するためのガス拡散板が設けられており、前記中性ラジカルを含む第1のガスとの気相化学反応によって前記被堆積基板に所望の膜を形成する第2のガスを、前記基板処理領域に導入する導入孔が前記プラズマ閉じ込め電極板に配置され、

前記プラズマ閉じ込め電極板と前記被堆積基板との垂直方向の距離が、基板処理領域における、前記中性ラジカルと前記第2のガスとの混合ガスの成膜時における平均自由行程 λ_g の1500倍以下となっていることを特徴とするプラズマCVD装置。

【請求項2】 前記ガス拡散板が、プラズマ閉じ込め電極内で互いに平行に位置する複数枚の拡散板であることを特徴とする請求項1記載のプラズマCVD装置。

【請求項3】 プラズマ生成領域において第1のガスのプラズマを形成する第1の過程と、

前記プラズマ生成領域において前記プラズマをプラズマ閉じ込め電極板により閉じ込める第2の過程と、

プラズマ閉じ込め電極板が、配置された孔を通して、前記プラズマから中性ラジカルを基板処理領域へ通過させる第3の過程と、

前記プラズマ閉じ込め電極板が、内部に設けられた、第2のガスを均一化するガス拡散板により、被堆積基板が設置される基板処理領域へ均一化された第2のガスを供給する第4の過程と、

前記中性ラジカルを含む第1のガスと前記第2のガスとの気相化学反応によって、被堆積基板に所望の膜を形成する第5の過程とを有し、

前記プラズマ閉じ込め電極板と前記被堆積基板との垂直方向の距離が、基板処理領域における成膜時平均自由行程 λ_g の1500倍以下となっていることを特徴とするプラズマCVD成膜方法。

【請求項4】 被堆積基板が設置される基板処理領域と、第1のガスのプラズマを形成するプラズマ生成領域と、前記基板処理領域とプラズマ生成領域とを分離して前記第1のガスのプラズマを閉じ込め、第1のガスの前記プラズマから中性ラジカルを含む第1のガスを通過させる孔が配置されたプラズマ閉じ込め電極板を有するプラズマCVD装置であって、

前記中性ラジカルを含む第1のガスとの気相化学反応によって、前記被堆積基板に所望の膜を形成する第2のガ

スを基板処理領域に導入する複数の導入孔が設けられたガス供給板を前記プラズマ閉じ込め電極板と前期被堆積基板との間に有し、

前記ガス供給板は中空構造であって、内部に第2のガスを板内で均一化するためのガス拡散板が設けられており、前記ガス供給板と前記被堆積基板の垂直方向の距離が基板処理領域における成膜時平均自由行程 λ_g の1500倍以下となっていることを特徴とするプラズマCVD装置。

10 【請求項5】 前記ガス拡散板が、ガス供給板内で互いに平行に位置する複数枚の拡散板であることを特徴とする請求項4記載のプラズマCVD装置。

【請求項6】 プラズマ生成領域において第1のガスのプラズマを形成する第1の過程と、

前記プラズマ生成領域において前記プラズマをプラズマ閉じ込め電極板により閉じ込める第2の過程と、

プラズマ閉じ込め電極板が、配置された孔を通して、前記プラズマから中性ラジカルを含む第1のガスをこのプラズマ閉じ込め電極板とガス供給板との間に供給する第3の過程と、

20 前記ガス供給板が、配置された複数の導入孔から中性ラジカルを含む第1のガスを基板処理領域へ通過させる第4の過程と、

前記ガス供給板が、内部に設けられた、第2のガスを均一化するガス拡散板により、被堆積基板が設置される基板処理領域へ均一化された第2のガスを供給する第5の過程と、

前記中性ラジカルを含む第1のガスと前記第2のガスとの気相化学反応によって、被堆積基板に所望の膜を形成する第6の過程とを有し、

30 前記ガス供給板と前記被堆積基板との垂直方向の距離が、基板処理領域における成膜時平均自由行程 λ_g の1500倍以下となっていることを特徴とするプラズマCVD成膜方法。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】本発明は、プラズマCVD装置およびこれを用いたプラズマCVD方法に関し、特に、プラズマ生成領域と基板処理領域とを分離するリモートプラズマCVD装置、およびリモートプラズマCVDによる大面積均一に緻密な膜の形成方法に係わるものである。

【0002】

【従来の技術】プラズマダメージを抑制しながら基板への膜形成を行うプラズマCVD装置の1つに、プラズマ生成領域と基板処理領域Rとを分離するリモートプラズマCVD装置がある。このリモートプラズマ装置を用いたCVD膜の形成は、半導体デバイスプロセスにおいて高信頼性デバイスや高性能デバイスを作製するための、薄膜作成の処理プロセスとして、非常に重要な技術とな

っている。

【0003】大面積フラットパネルディスプレイのスイッチングトランジスタ形成プロセスと駆動回路トランジスタ形成プロセス、および大口径シリコンウエハプロセスなどの大型基板に対応できるリモートプラズマCVD装置としては、例えば特開平5-21393に開示されているような平行平板リモートプラズマCVD装置が開示されている。

【0004】この従来例のリモートプラズマCVD装置における、平行平板型リモートプラズマCVD装置は、図7に示すように、従来の平行平板プラズマCVD装置において基板3の設置される対向電極2と高周波印加電極1との間に、複数の孔が開いたメッシュプレートを用いたプラズマ閉じ込め電極8が設けられている。そして、平行平板型リモートプラズマCVD装置は、このプラズマ閉じ込め電極8と高周波印加電極1との間でプラズマ6を閉じこめるものである。プラズマ閉じ込め電極8と高周波印加電極1の平行平板間で閉じこめた大面積均一なプラズマ6から、基板処理領域Rに中性ラジカル4などのガスを供給するため、基板処理領域Rに供給された中性ラジカル4などの基板直上面内分布は大面積均一となり、基板3における薄膜形成処理が大面積基板に対して均一に行えるという特長を有する。

【0005】さらに、上述の従来例においては、メッシュプレートの孔、すなわちラジカル4の通過孔5の付近に、中性ガス10を噴射する中性ガス噴射孔9が設けられており、ラジカル4と中性ガス10との気相反応を用いるプロセスにおいても、基板3に対する膜の生成処理において大面積均一な処理が可能となっている。

【0006】すなわち、図7に示す平行平板リモートプラズマCVD装置により、基板処理領域Rにおいて気相化学反応を伴う成膜（薄膜の生成処理）を行う場合には、反応に寄与する第1のガスのプラズマ（プラズマ6）を形成し、このプラズマからプラズマ閉じ込め電極8のラジカル通過孔5を通し、励起された第1のガスのラジカル（ラジカル4）及び励起されていない第1のガスを基板処理領域Rに供給し、中性ガス噴射孔9から供給される第2のガスと反応させて、薄膜生成に必要な成膜前駆体を形成する。

【0007】例えば、モノシラン（ SiH_4 ）と酸素（ O_2 ）との反応による酸化シリコン成膜を行う場合には、第1のガスを酸素とし、第2のガスをモノシランとする。このとき、ラジカル通過孔5及び中性ガス噴射孔9が、プラズマ閉じ込め電極8に多数開口されているため、第2のガス（中性ガス10）が多数の中性ガス噴射孔9から均一に供給されれば、基板処理領域Rにおける上記気相反応は、基板3の直上面内で均一に起こり、基板3の表面に均一な膜を形成することができる。

【0008】上述してきた理由から、平行平板型リモートプラズマCVD装置は、大型ガラス基板上に薄膜トラ

ンジスタのゲート絶縁膜となる酸化シリコン（ SiO_2 ）膜や窒化シリコン膜（ Si_3N_4 もしくは Si_xN_y ）、同じく大型ガラス基板上に薄膜トランジスタの活性層やゲート電極となる非晶質シリコン膜、さらに大型Si基板上にトランジスタ素子の層間絶縁膜となる酸化シリコン膜や窒化シリコン膜などを成膜する方法として有望視されている。

【0009】

【発明が解決しようとする課題】上述したようにラジカル通過孔5の付近に中性ガス噴射孔9を設けて、中性ガス噴射孔9から面内均一な中性ガス10の供給を行おうとすると、上述した従来例（特開平5-21393）に開示されているように、中空構造のプラズマ閉じ込め電極8を用いることになる。この中空構造のプラズマ閉じ込め電極8においては、図8の閉じ込め電極側面図および図9の閉じ込め電極上面図に示すようにラジカル通過孔5と中性ガス通過孔9とが各々独立に（分離されて）設けられており、中空領域内でラジカル4と中性ガス10とが混ざり、中空領域内でラジカル4と中性ガス10とが反応することはない。

【0010】ここで中空構造のプラズマ閉じ込め電極8に真空チャンバ外部から中性ガス10を供給する方法として、従来例において開示されているのは、図9または図10に示すように、プラズマ閉じ込め電極8側面部に設けられた中性ガス導入管12から、中性ガス10をプラズマ閉じ込め電極8の中空領域内に供給する方法である。

【0011】この従来例の方法では、プラズマ閉じ込め電極8における中空部内の圧力が基板処理領域Rの成膜圧力と同程度、すなわち数十mTorr～数百mTorrと低圧である。このため図11の概念図に模式的に示すように、中性ガス導入管12とプラズマ閉じ込め電極8との接続部付近の中性ガス噴射孔9から大部分の中性ガス10が噴射されてしまい、中性ガス導入管12から遠い噴射孔9からは少量の中性ガス10しか噴射されなくなるので、基板3の表面に面内均一な中性ガス10の噴射が困難となってしまいうという欠点がある。

【0012】このように、表面への面内均一な中性ガス10の噴射が困難な状況において、基板3表面に面内均一な膜を形成するためには、中性ガス10を噴射するプラズマ閉じ込め電極8と基板3との距離Dを長くすればよい。すなわち、第2のガス（中性ガス10）が面内不均一に基板処理領域Rに供給され、第1のガスと気相化学反応を起こすと、第2のガスが供給された付近では、気相化学反応の結果生成された反応生成物（成膜前駆体）の基板3直上面内分布も不均一となる。

【0013】しかしながら、上記距離Dが長ければ、第2のガスおよび反応生成物が基板3まで移動する間に、基板3表面に対して平行な方向へ拡散する時間が十分与えられるので、基板3表面に到達する時点では、基板3

表面における面内分布が均一化する。この成膜方法においては、CVDチャンバの幅Wに対して、プラズマ閉じ込め電極8と基板3との距離Dが大きいと均一化作用を得やすくなる。

【0014】例えば、500mm×600mmのガラス基板に成膜を行う場合には、CVDチャンバの幅Wは、800mm程度になり、プラズマ閉じ込め電極と基板との距離D13を同じ長さの800mm程度にすると十分に均一化作用が現れる。しかしながら気相化学反応による成膜においては、上述のように中性ガス10を噴射する噴射孔9の設けられたプラズマ閉じ込め電極8と、被堆積基板（基板3）との距離Dを長くしてしまうと、中性ラジカルを含む第1のガスと第2のガスとの気相反応が過剰に進み、基板処理領域Rにおける気相中で、粒（成膜前駆体）成長が進んでしまい、この成長した粒が被堆積基板表面に堆積するため、生成された膜が疎密になりやすいという問題が生じる。

【0015】例えば、モノシランと酸素の気相化学反応による酸化シリコン成膜を行う場合には、基板処理領域Rにおける気相中で、パーティクル状のSiO_x粒（成膜前駆体）が成長することになる。上述の様に生成された疎密な膜は欠陥密度が高いため、リーク電流が大きく絶縁耐圧も低くなるため、薄膜トランジスタのゲート絶縁膜などに使用することはできない。

【0016】本発明は、このような背景の下になされたもので、気相化学反応によるリモートプラズマCVD方法での成膜において、過剰な気相化学反応による粒成長を起こさずに、被堆積基板上に緻密で面内均一な膜堆積が行える、成膜前駆体を供給することのできるリモートプラズマCVD装置およびリモートプラズマCVD成膜法を提供する事にある。

【0017】

【課題を解決するための手段】上記の目的を達成するため本発明は、第2のガスを基板処理領域に導入する導入孔が配置されたプラズマ閉じ込め電極板と被堆積基板の垂直方向の距離が、基板処理領域における成膜時平均自由行程λgの1500倍以下となっており、かつ前記プラズマ閉じ込め電極板は中空構造であって第2のガスを板内で均一化するためのガス拡散板が設けられていることを特徴としている。拡散板によりプラズマ閉じ込め電極板内で第2のガスが均一化されて基板処理領域に導入されるため、基板直上面内での均一な気相化学反応が起こり、かつ第2ガスが基板処理領域に導入されてから基板に到達するまでに起こる様々な素化学反応の回数が制限され、過剰反応による気相での粒成長が問題ないレベルに抑制されるため、被堆積基板上に面内均一で緻密な膜を形成することが出来る。また本発明では、第2のガスを基板処理領域に導入する導入孔が配置されプラズマ閉じ込め電極と被堆積基板の間に位置するガス供給板と被堆積基板の垂直方向の距離が、基板処理領域における

成膜時平均自由行程λgの1500倍以下となっており、かつ前記ガス供給板は中空構造であって第2のガスを板内で均一化するためのガス拡散板が設けられていることを特徴としている。拡散板によりガス供給板内で第2のガスが均一化されて基板処理領域に導入されるため、基板直上面内での均一な気相化学反応が起こり、かつ第2ガスが基板処理領域に導入されてから基板に到達するまでに起こる様々な素化学反応の回数が制限され、過剰反応による気相での粒成長が問題ないレベルに抑制されるため、被堆積基板上に面内均一で緻密な膜を形成することが出来る。

【0018】請求項1記載の発明は、プラズマCVD装置において、被堆積基板が設置される基板処理領域と、第1のガスのプラズマを形成するプラズマ生成領域と、前記基板処理領域とプラズマ生成領域とを分離して前記第1のガスのプラズマを閉じ込め、第1のガスの前記プラズマから中性ラジカルを含む第1のガスを通させる孔が配置されたプラズマ閉じ込め電極板を有するプラズマCVD装置であって、前記プラズマ閉じ込め電極板が中空構造であり、内部に第2のガスをこのプラズマ閉じ込め電極板内で均一化するためのガス拡散板が設けられており、前記中性ラジカルとの気相化学反応によって前記被堆積基板に所望の膜を形成する第2のガスを、前記基板処理領域に導入する導入孔が前記プラズマ閉じ込め電極板に配置され、前記プラズマ閉じ込め電極板と前記被堆積基板との垂直方向の距離が、基板処理領域における成膜時平均自由行程λgの1500倍以下となっていることを特徴とする。

【0019】請求項2記載の発明は、請求項1記載のプラズマCVD装置において、前記ガス拡散板が、プラズマ閉じ込め電極内で互いに平行に位置する複数枚の拡散板であることを特徴とする。

【0020】請求項3記載の発明は、プラズマCVD成膜方法において、プラズマ生成領域において第1のガスのプラズマを形成する第1の過程と、前記プラズマ生成領域において前記プラズマをプラズマ閉じ込め電極板により閉じ込める第2の過程と、プラズマ閉じ込め電極板が、配置された孔を通して、前記プラズマから中性ラジカルを含む第1のガスを基板処理領域へ通過させる第3の過程と、前記プラズマ閉じ込め電極板が、内部に設けられた、第2のガスを均一化するガス拡散板により、被堆積基板が設置される基板処理領域へ均一化された第2のガスを供給する第4の過程と、前記中性ラジカルを含む第1のガスと前記第2のガスとの気相化学反応によって、被堆積基板に所望の膜を形成する第5の過程とを有し、前記プラズマ閉じ込め電極板と前期被堆積基板との垂直方向の距離が、基板処理領域における成膜時平均自由行程λgの1500倍以下となっていることを特徴とする。

【0021】請求項4記載の発明は、プラズマCVD装

置において、被堆積基板が設置される基板処理領域と、第1のガスのプラズマを形成するプラズマ生成領域と、前記基板処理領域とプラズマ生成領域とを分離して前記第1のガスのプラズマを閉じ込め、第1のガスの前記プラズマから中性ラジカルを含む第1のガスを通過させる孔が配置されたプラズマ閉じ込め電極板を有するプラズマCVD装置であって、前記中性ラジカルを含む第1のガスとの気相化学反応によって、前記被堆積基板に所望の膜を形成する第2のガスを基板処理領域に導入する複数の導入孔が設けられたガス供給板を前記プラズマ閉じ込め電極板と前記被堆積基板との間に有し、前記ガス供給板は中空構造であって、内部に第2のガスを板内で均一化するためのガス拡散板が設けられており、前記ガス供給板と被堆積基板の垂直方向の距離が基板処理領域における成膜時平均自由行程 λ_g の1500倍以下となっていることを特徴とする。

【0022】請求項5記載の発明は、請求項4記載のプラズマCVD装置において、前記ガス拡散板が、ガス供給板内で互いに平行に位置する複数枚の拡散板であることを特徴とする。

【0023】請求項6記載の発明は、プラズマCVD成膜方法において、プラズマ生成領域において第1のガスのプラズマを形成する第1の過程と、前記プラズマ生成領域において前記プラズマをプラズマ閉じ込め電極板により閉じ込める第2の過程と、プラズマ閉じ込め電極板が、配置された孔を通して、前記プラズマから中性ラジカルを含む第1のガスをこのプラズマ閉じ込め電極板とガス供給板との間に供給する第3の過程と、前記ガス供給板が、配置された複数の導入孔から中性ラジカルを含む第1のガスを基板処理領域へ通過させる第4の過程と、前記ガス供給板が、内部に設けられた、第2のガスを均一化するガス拡散板により、被堆積基板が設置される基板処理領域へ均一化された第2のガスを供給する第5の過程と、前記中性ラジカルを含む第1のガスと前記第2のガスとの気相化学反応によって、被堆積基板に所望の膜を形成する第6過程とを有し、前記ガス供給板と前記被堆積基板との垂直方向の距離が、基板処理領域における成膜時平均自由行程 λ_g の1500倍以下となっていることを特徴とする。

【0024】

【発明の実施の形態】以下、図面を参照して本発明の実施形態について説明する。図1は本発明の一実施形態によるリモートプラズマCVD（化学的気相成長）装置の構成の断面を示す概念図である。本発明の一実施形態を酸素/シラン系の平行平板リモートプラズマCVD装置における酸化シリコン膜形成を例にとり、以下に図を参照して詳細に説明する。従来例と同様な構成については、同一の符号を付し、この構成の説明を省略する。

【0025】この図において、平行平板リモートプラズマCVD装置は、基本的には図1に示すように、真空排

気可能な真空チャンバ、高周波電源13、高周波印加電極1、基板3を支持する対向電極2、中性ラジカルを含むガスを通過（導入）させるラジカル通過孔5及び中性ガス噴射孔5が設けられ、かつ電気的に接地されたプラズマ閉じ込め電極20を備え、かつ、プラズマ閉じ込め電極20の側面から中性ガス（例えば、モノシラン19）を導入する中性ガス導入管12によって構成されている。

【0026】また、プラズマ閉じ込め電極20には、内部にラジカル通過孔及び中性ガス噴射孔を有する拡散板が設けられている。この拡散板を有するプラズマ閉じ込め電極20の断面概略図を図2に示す。この図において、プラズマ閉じ込め電極上部板26とプラズマ閉じ込め電極下部板27とに挟まれた中空部に、モノシランガス（中性ガス）19を均一に拡散するための複数のガス拡散板、すなわち一実施形態では第1のガス拡散板23及び第2のガス拡散板24が設けられて（配置されて）いる。

【0027】図2においては、プラズマ閉じ込め電極上部板26と第1のガス拡散板23との間にモノシランガス19が供給され、モノシランガス19が第1のガス拡散板23の孔9Aによって均一化され、さらに第2のガス拡散板24の孔9Bによって均一化され、最後にプラズマ閉じ込め電極下部板27に設けられた中性ガス噴射孔9から、面内均一にモノシランガス19が基板3に向かって噴射される。

【0028】ここで、孔9A、孔9B及び中性ガス噴射孔9と、ラジカル通過孔5とは、酸素ラジカル及び酸素分子21とモノシランガス19とが混合されないように、分離されて（独立して）、プラズマ閉じ込め電極20内において、各々設けられている。上記の分離を行うために、ラジカル通過孔5は、モノシランの存在する領域から隔離する壁で形成された繋がった孔であり、かつプラズマ閉じ込め電極上部板26とプラズマ閉じ込め電極下部板27の間を貫通している。なお、図2では第1の拡散板23と第2の拡散板24との2枚の拡散板を示しているが、この拡散板は1枚でも2枚以上の複数枚でも何枚でも良い。

【0029】プラズマ閉じ込め電極上部板26からプラズマ閉じ込め電極下部板27の間に貫通されたラジカル通過孔5の開孔孔径は、発生させた酸素プラズマ22を効率よく閉じ込められるように、発生させた酸素プラズマ22におけるプラズマのデバイ長の2倍以下程度の長さ設定されている。

【0030】次に、図3は、プラズマ閉じ込め電極上部板26とプラズマ閉じ込め電極下部板27の平面図を示したものである。図3(a)はプラズマ閉じ込め電極上部板26の平面図を示し、図3(b)はプラズマ閉じ込め電極下部板27の平面図を示している。

【0031】ここで、図3(a)において、プラズマ閉

じ込め電極上部板26には、閉じ込められた酸素プラズマ22から、中性ラジカルを含むガスを通過させるラジカル通過孔5が所定の間隔に板内で均一に開孔されている。また、図3(b)において、プラズマ閉じ込め電極下部板27には、閉じ込められた酸素プラズマ22から、中性ラジカルを含むガスを通過させるラジカル通過孔5が所定の間隔に板内均一に開孔され、このラジカル通過孔5と一致しない位置に、中性ガス噴射孔9が所定の間隔に板内均一に開孔されている。

【0032】次に、図4は、ガス拡散板(第1のガス拡散板23及び第2のガス拡散板24)の平面図を示している。ここで、上記2枚のガス拡散板、第1のガス拡散板23及び第2のガス拡散板24は、図2の第1のガス拡散板23と第2のガス拡散板24に対応している。

【0033】図4(a)において、第1のガス拡散板23には、中性ラジカルを含むガスを通過させるラジカル通過孔5が所定の間隔に板内で均一に開孔され、中性ガス通過孔9が、中心付近の所定の領域Qの、ラジカル通過孔5と一致しない位置に、均一に開孔されている。また、図4(b)において、第2のガス拡散板24には、中性ラジカルを含むガスを通過させるラジカル通過孔5が所定の間隔に板内で均一に開孔され、中性ガス通過孔9が、中心付近の所定の領域Pの、ラジカル通過孔5と一致しない位置に、均一に開孔されている。

【0034】ここで、領域Pは、第1のガス拡散板23と第2のガス拡散板24とを、プラズマ閉じ込め電極20に設置するときこの2枚の拡散板を重ねた場合、平面視において上記領域Qを含み、かつ領域Qより広い領域を示す。すなわち、第2のガス拡散板24において、中性ガス通過孔9が第1のガス拡散板23での開孔位置と同様の位置に開孔されているだけではなく、さらにその外周領域にも中性ガス通過孔9が開孔されている。

【0035】拡散板内全面において、均一に中性ガス通過の孔を開口してもよいが、上述したように、図4に示すように複数の重ねられる拡散板の孔の位置を工夫することにより、図11に示すように中性ガス導入管12付近で大量のガスが基板処理領域Rに噴射されてしまうのを防ぐことができ、基板3の表面に対して、より面内均一な中性ガス(例えばモノシランガス19等)の供給を行うことができる。

【0036】また、拡散板の構成において、第1のガス拡散板23と第2のガス拡散板24とを、プラズマ閉じ込め電極20に設置するときこの2枚の拡散板を重ねた場合、複数の拡散板同士のモノシランガス(中性ガス)19を流す孔、すなわち孔9Aと孔9Bとが、平面視において重ならないように(直線上に位置しないように)設ける構成も可能である。

【0037】次に、図1、図2、図3および図4を参照して、本発明の一実施形態によるリモートプラズマCVD装置による、基板3表面への酸化シリコン膜の形成方

法について、以下に説明する。真空排気状態にある(所定の圧力となっている)CVDチャンバ内で、高周波印加電極1に酸素ガス18を導入し、この酸素ガス18が高周波印加電極1の下面からプラズマ閉じ込め電極20の方向に均一に供給され、拡散板(図4に示す第1のガス拡散板23及び第2の拡散板24)を有するプラズマ閉じ込め電極20との間で、高周波電源13から高周波印加電極1に供給される高周波によりグロー放電を起こさせる。

【0038】このグロー放電により発生された酸素プラズマ22は、高周波印加電極1とプラズマ閉じ込め電極20との間で効率よく閉じこめられる。その結果、例えば、酸素プラズマ22におけるプラズマ密度が 10^{10} cm^{-3} 程度であるのに対し、プラズマ閉じ込め電極20と対向電極2(または基板3)との間のプラズマ密度は $10^3 \text{ cm}^{-3} \sim 10^6 \text{ cm}^{-3}$ 程度となっている。

【0039】すなわち、酸素プラズマ22中には、電子、酸素原子イオン、酸素分子イオン、酸素原子ラジカル、酸素分子ラジカル、酸素分子が存在するが、プラズマ外に侵入する電子およびイオンは無視できる程度の量であることを示している。したがって、酸素プラズマ22外において、すなわち基板処理領域Rに噴射されるモノシランガス19と反応し、酸化シリコン膜成膜に寄与するのは、酸素原子ラジカル、酸素分子ラジカル、および励起されない酸素分子である。

【0040】そして、酸素ラジカルおよび酸素分子21は、ラジカル通過孔5を通して基板処理領域Rに拡散し、中性ガス噴射孔9から噴射されたモノシランガス19と気相化学反応を起こす。この気相化学反応により、 SiO_x 、 SiO_xHy 、 SiHy などの酸化シリコン前駆体(成膜前駆体)が形成され、この形成された酸化シリコン前駆体が基板3表面に堆積されることにより、基板3表面に酸化シリコン膜を形成する。

【0041】ここでプラズマ閉じ込め電極20と基板3との距離D(垂直方向の距離)は、基板処理領域Rにおける酸素(酸素ラジカルおよび酸素分子21)/モノシラン混合ガスの平均自由行程 λ_g の1500倍以下(ただし、「0」を超える数)になるよう設定されている。この距離Dにより、気相化学反応が、過剰に進むのを抑制しているため、 SiO_x 、 SiO_xHy 、 SiHy などの酸化シリコン膜前駆体が、基板処理領域Rにおける気相で、粒成長することによって、パーティクル状の大きさに成長することがない。

【0042】例えば、ガス温度300℃、チャンバ圧力250mTorrにおいて、酸素/モノシラン混合ガスの平均自由行程 λ_g は約60μmであるため、プラズマ閉じ込め電極と基板との距離Dは90mm以下とすればよい。実際に、酸化シリコン膜の成膜を行った例として、基板温度300℃、基板処理領域R圧力250mTorr、高周波印加電極1を通してプラズマ領域へ供給

する酸素流量800 sccm、中性ガス導入管12へ供給するモノシランガス流量5 sccmの条件で成膜した酸化シリコン膜を、MOS（金属・酸化膜・半導体）キャパシタのゲート絶縁膜としたときのリーク電流特性を図5に示す。

【0043】図5において、プラズマ閉じ込め電極20と基板3との距離Dを、300 mmにした場合と、60 mmにした場合とで、リーク電流密度値が大きく変わっている。すなわち、プラズマ閉じ込め電極20と基板3との距離Dを、60 mmとして形成した膜のリーク電流特性は、シリコン熱酸化膜の電流特性に近く、良好であり、薄膜トランジスタのゲート絶縁膜や層間絶縁膜として用いることが可能な電氣的絶縁特性及び耐圧を有している。

【0044】これに対して、プラズマ閉じ込め電極20と基板3との距離Dを、300 mmとして形成した膜のリーク電流特性は、低電界領域から大きなリーク電流が流れており、薄膜トランジスタのゲート絶縁膜や層間絶縁膜には、電氣的絶縁特性及び耐圧が低く、用いることができない。

【0045】上述した実験条件において、基板処理領域Rにおける酸素／モノシラン混合ガスの平均自由工程λgは、約60 μmである。このとき、電氣的絶縁特性及び耐圧が低い方のプラズマ閉じ込め電極20と基板3との距離D、すなわち、300 mmは、上記平均自由工程λgの約5000倍に相当する。

【0046】一方、電氣的絶縁特性及び耐圧が低い方のプラズマ閉じ込め電極20と基板3との距離D、すなわち60 mmは、上記平均自由工程λgの約1000倍に相当する。上記平均自由工程λgの5000倍もプラズマ閉じ込め電極20と基板3との距離Dが大きいと、酸素ラジカルおよび酸素分子21と、モノシランガス19との気相化学反応が進みすぎ、基板処理領域Rにおける気相中で粒成長したパーティクルが基板3表面に膜として堆積し、基板3表面に粗密な膜を形成してしまったと推察される。

【0047】これに対して、上記平均自由工程λgの1000倍程度のプラズマ閉じ込め電極20と基板3との距離Dであれば、酸素ラジカルおよび酸素分子21と、モノシランガス19との気相化学反応は進みすぎることが無く、気相中での粒成長が制限され、基板3表面においてパーティクル状の酸化シリコン膜前駆体が膜として堆積することはないと推察される。

【0048】また、上述したように、プラズマ閉じ込め電極20と対向電極2との間のプラズマ密度は非常に低くなっているために、通常の平行平板プラズマCVDに比べて基板3へのプラズマダメージは非常に低く抑えられている。

【0049】この効果は、基板3の表面がMOS界面を形成するシリコン表面の場合には、顕著に現れ、通常の

平行平板プラズマCVDで単結晶シリコン基板上にSiO₂膜を形成した場合に、そのMOS界面準位密度がミッドギャップ付近で $10^{11} \sim 10^{12} \text{ cm}^{-2} \text{ eV}^{-1}$ であるのに対し、平行平板リモートプラズマCVDで酸化シリコン膜を形成した場合には、 $\sim 10^{10} \text{ cm}^{-2} \text{ eV}^{-1}$ 程度の低い界面準位密度となる。

【0050】以上、本発明の一実施形態を図面を参照して詳述してきたが、具体的な構成はこの実施形態に限られるものではなく、本発明の要旨を逸脱しない範囲の設計変更等があっても本発明に含まれる。例えば、図6を用いて、第2の実施形態による平行平板リモートプラズマCVDを説明する。図6は、平行平板リモートプラズマCVD装置の構成の断面を示す概念図である。従来例及び一実施形態と同様な構成については、同一の符号を付し、この構成の説明を省略する。

【0051】この図において、図6の平行平板リモートプラズマCVD装置が、図1の平行平板リモートプラズマCVD装置と異なるのは、中性ガス導入管12が接続されて中性ガス（モノシランガス19）をその中に導入し、内部に設けられたガス拡散板でガス濃度を均一化して基板側へ噴射するガス供給板29がプラズマ閉じ込めの機能を有しないことである。

【0052】このため、拡散板を有するガス供給板29のラジカル通過孔5は、ラジカル4の均一噴射が可能であればその孔径は任意である。また、電氣的に接地せずに電氣的浮遊状態で使用することも可能である。すなわち、ガス供給板29は、構成自体は一実施形態におけるプラズマ閉じ込め電極20と同様であるが、接地されていない点とラジカル通過孔の孔径が異なる。

【0053】なお、このガス供給板29は、プラズマ閉じ込め電極8と対向電極2との間に位置しており、ガス供給板29と基板3との距離Fが基板処理領域Rにおける酸素（酸素ラジカル及び酸素分子21）／モノシラン混合ガスの平均自由工程λgの1500倍以下（ただし、「0」を超える数）になるよう設定されている。

【0054】上記以外については、第2の実施形態における、拡散板を有するガス供給板29と、一実施形態における、拡散板を有するプラズマ閉じ込め電極20とは、同様の構造を有している。また、ガス供給板29内のガス拡散板の構造及びガス拡散板の数、ガス拡散板におけるラジカル通過孔及び中性ガスを通させる孔の分布の関係などに関する考え方は、一実施形態におけるプラズマ閉じ込め電極20内に設けられるガス拡散板（第1のガス拡散板及び第2のガス拡散板）と同様である。

【0055】また、ガス供給板29と基板3との距離Fに対する考え方も、一実施形態におけるプラズマ閉じ込め電極20と基板3との距離Dに関する考え方と同様であり、酸素ラジカルおよび酸素分子21と、モノシランガス19の気相化学反応が進みすぎることが無く、気相中での粒成長が制限され、パーティクルが膜として基板

3の表面に堆積することはない。

【0056】以上の一実施形態及び第2の実施形態においては、モノシランと酸素を用いた酸化シリコン膜形成を例にあげて本発明の説明を行ったが、モノシランのかわりにジシランなどの高次シランやTEOS (Tetraethoxysilane) などの液体Si原料などでもよく、酸素のかわりに亜酸化窒素、酸化窒素などを用いても良い。

【0057】また、上述した一実施形態及び第2の実施形態におけるリモートプラズマCVD装置は、酸化シリコン膜形成を例にあげて説明を行ったが、モノシランとアンモニアとの反応による窒化シリコン膜形成など、他の材料系の気相化学反応を伴うプラズマCVD成膜に用いても、生成された膜に対して、一実施形態及び第2の実施形態で生成された膜と同様の効果を得ることができる。

【0058】さらに以上の実施の形態においては、平行平板リモートプラズマCVD装置を用いた例をあげたが、本発明は、プラズマ生成領域と基板処理領域Rとの間に複数の孔が設けられた、プラズマ分離用のプラズマ閉じ込め電極を有するプラズマCVD装置であれば、マイクロ波プラズマ、電子サイクロトロン共鳴プラズマ、誘導結合プラズマ、ヘリコン波プラズマを用いたプラズマCVD装置など、どのような形態の装置であっても適用される。

【0059】

【発明の効果】本発明のリモートプラズマCVD装置によれば、気相化学反応により成膜を行うリモートプラズマCVDにおいて、気相化学反応の過剰な進行を抑制することができ、かつ、プラズマ領域外で噴射する中性ガスの濃度を、被堆積基板上において均一にすることができる。したがって、本発明のリモートプラズマCVD装置によれば、MOS素子のゲート絶縁膜や層間絶縁膜を作製する際、パーティクルなどを含まない緻密な膜を大面積基板に均一に形成することができる。

【図面の簡単な説明】

【図1】 本発明の第1の実施の形態における平行平板リモートプラズマCVD装置の側面概略図である。

【図2】 本発明の第1の実施の形態における、拡散板を有するプラズマ閉じ込め電極の断面概略図である。

【図3】 本発明の第1の実施の形態における、拡散板を有するプラズマ閉じ込め電極の上部板と下部板の平面概略図である。

【図4】 本発明の第1の実施の形態における拡散板の

平面概略図である。

【図5】 堆積した酸化シリコン膜のリーク電流特性を示した図である。

【図6】 本発明の第2の実施の形態における平行平板リモートプラズマCVD装置の側面概略図である。

【図7】 従来例における平行平板リモートプラズマCVD装置の側面概略図である。

【図8】 従来例における中空構造のプラズマ閉じ込め電極の断面概略図である。

10 【図9】 従来例における中空構造のプラズマ閉じ込め電極の平面概略図である。

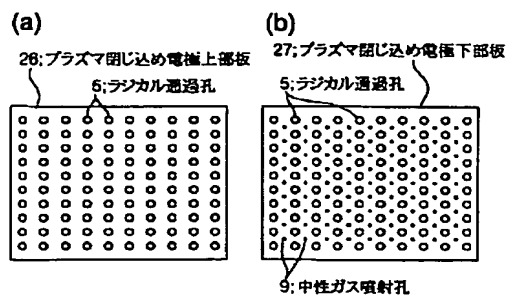
【図10】 従来例において、中空構造のプラズマ閉じ込め電極に真空チャンバ外部より中性ガスを供給する方法を示した、平行平板リモートプラズマCVD装置の側面概略図である。

【図11】 従来例における中空構造のプラズマ閉じ込め電極において、ガスの噴射の様子を示すプラズマ閉じ込め電極の断面概略図である。

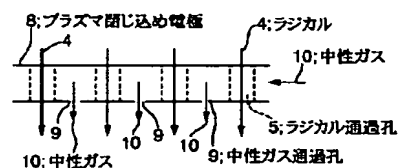
【符号の説明】

- | | |
|-------|-------------------------------|
| 1 | 高周波印加電極 |
| 2 | 対向電極 |
| 3 | 基板 |
| 4 | ラジカル |
| 5 | ラジカル通過孔 |
| 6 | プラズマ |
| 7 | チャンバ壁 |
| 8 | プラズマ閉じ込め電極 |
| 9 | 中性ガス噴射孔 |
| 10 | 中性ガス |
| 30 11 | プラズマ分解用中性ガス |
| 12 | 中性ガス導入管 |
| 13 | 高周波電源 |
| 16 | 真空排気 |
| 18 | 酸素ガス |
| 19 | モノシランガス |
| 20 | 拡散板を有するプラズマ閉じ込め電極(プラズマ閉じ込め電極) |
| 21 | 酸素ラジカルおよび酸素分子 |
| 22 | 酸素プラズマ |
| 40 23 | 第1のガス拡散板 |
| 24 | 第2のガス拡散板 |
| 26 | プラズマ閉じ込め電極上部板 |
| 27 | プラズマ閉じ込め電極下部板 |
| 29 | 拡散板を有するガス供給板 |

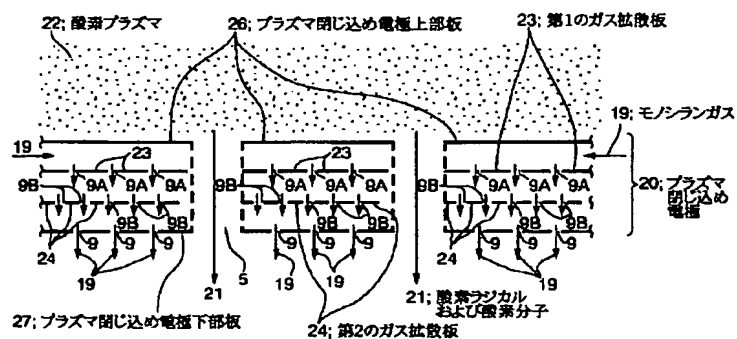
【圖 3】



【圖 8】

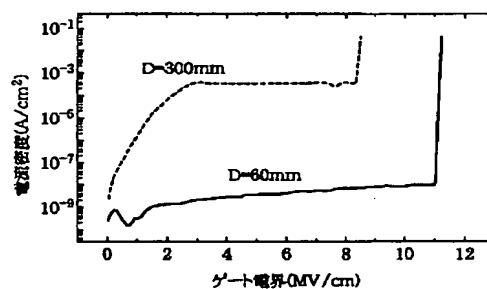
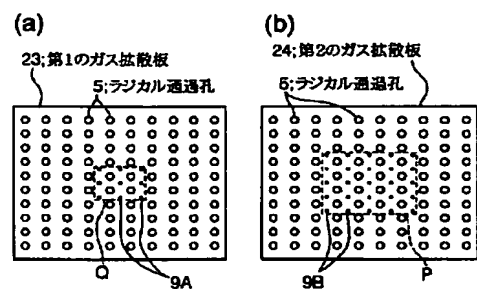


【圖2】

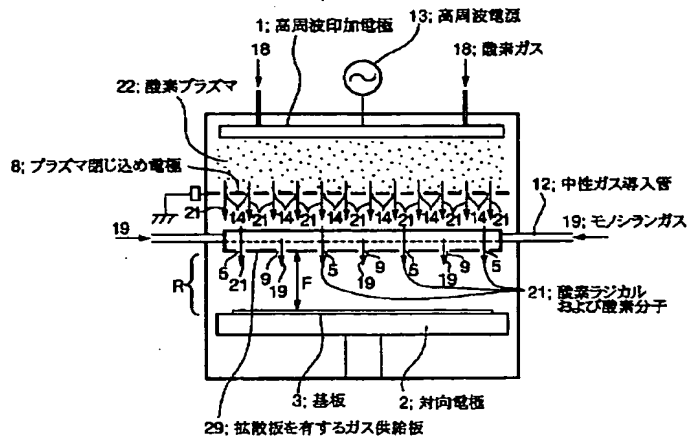


【図4】

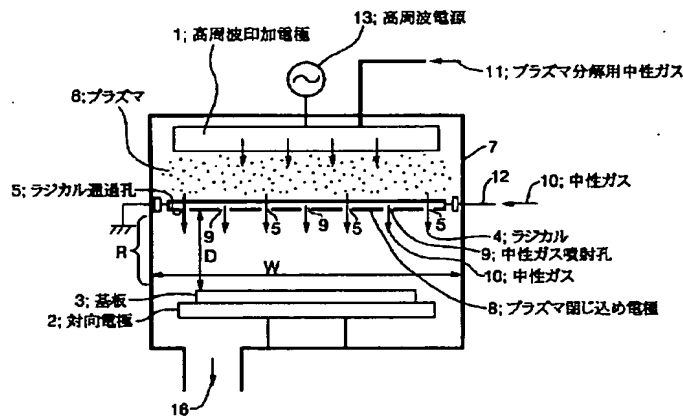
【圖5】



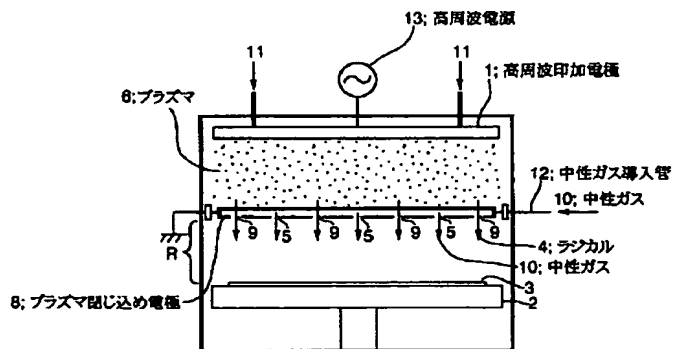
【図6】



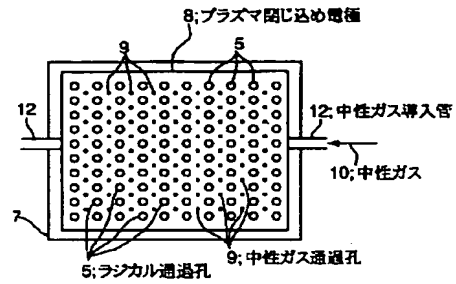
【図7】



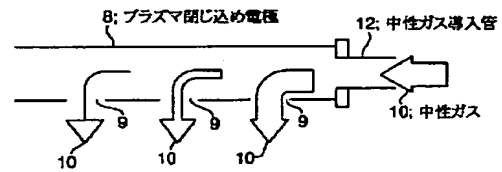
【図10】



【図9】



【図11】



フロントページの続き

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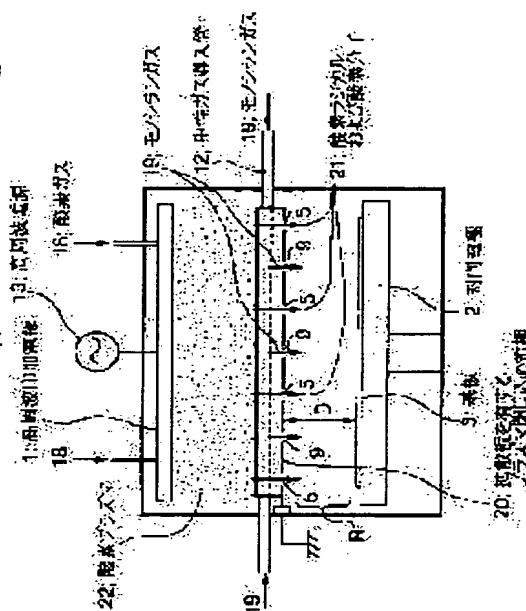
(72)Inventor : YUDA KATSUHIKA

(54) PLASMA CVD SYSTEM AND PLASMA CVD FILM DEPOSITION METHOD

(57)Abstract:

PROBLEM TO BE SOLVED: To reconcile the suppression of the surplus progression of vapor phase chemical reaction and uniform film deposition in a remote plasma CVD in which film deposition is executed by using vapor phase chemical reaction.

SOLUTION: In remote plasma CVD in which gaseous oxygen 18 is fed to a high-frequency applying electrode 1, oxygen radicals and oxygen molecules 21 are brought into reaction with gaseous monosilane 19 introduced in a substrate treating region R other than oxygen plasma 22, and the surface of a substrate 3 is deposited with a film, the distance between a plasma confining electrode 20 arranged with an introducing port introducing the gaseous monosilane 19 into the substrate treating region R and the vertical direction of the substrate 3 (the substrate to be deposited) is controlled to ≤ 1500 times the average free path λg at the time of film deposition in the substrate treating region R, and also, the plasma confining electrode 20 is provided with gas diffusion boards each with a hollow structure (a first gas diffusion board and a second gas diffusion board) for uniformizing the gaseous monosilane 19 (neutral gas) in the boards.



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CLAIMS

[Claim(s)]

[Claim 1] The substrate processing field in which a deposited substrate is installed, and the plasma production field which forms the plasma of the 1st gas, Separate said substrate processing field and plasma production field, and the plasma of said 1st gas is shut up. It is plasma-CVD equipment which has the plasma confinement electrode plate with which the hole which passes the 1st gas which contains a neutral radical from said plasma of the 1st gas has been arranged. Said plasma confinement electrode plate is hollow structure, and the gaseous diffusion plate for equalizing the 2nd gas within this plasma confinement electrode plate is formed in the interior. The 2nd gas which forms the desired film in said deposited substrate by the gaseous-phase chemical reaction with the 1st gas containing said neutral radical The introductory hole introduced into said substrate processing field is arranged at said plasma confinement electrode plate. Plasma-CVD equipment characterized by the distance of the perpendicular direction of said plasma confinement electrode plate and said deposited substrate being 1500 or less times of mean free path λ_{dag} at the time of membrane formation of the mixed gas of said neutral radical in a substrate processing field, and said 2nd gas.

[Claim 2] Plasma-CVD equipment according to claim 1 characterized by said gaseous diffusion plates being two or more diffusion plates mutually located in parallel within a plasma confinement electrode.

[Claim 3] The 1st process which forms the plasma of the 1st gas in a plasma production field, The 2nd process which shuts up said plasma with a plasma confinement electrode plate in said plasma production field, The 3rd process in which a plasma confinement electrode plate lets the arranged hole pass, and a neutral radical is passed from said plasma to a substrate processing field, Said plasma confinement electrode plate with the gaseous diffusion plate which was formed in the interior and which equalizes the 2nd gas By the gaseous-phase chemical reaction of the 4th process which supplies the 2nd gas equalized to the substrate processing field in which a deposited substrate is installed, the 1st gas containing said neutral radical, and said 2nd gas The plasma-CVD membrane formation approach characterized by having the 5th process which forms the desired film in a deposited substrate, and the distance of the perpendicular direction of said plasma confinement electrode plate and said deposited substrate having become 1500 or less times of mean free path λ_{dag} at the time of the membrane formation in a substrate processing field.

[Claim 4] The substrate processing field in which a deposited substrate is installed, and the plasma production field which forms the plasma of the 1st gas, Separate said substrate processing field and plasma production field, and the plasma of said 1st gas is shut up. By the gaseous-phase chemical reaction with the 1st gas which is plasma-CVD equipment which has the plasma confinement electrode plate with which the hole which passes the 1st gas which contains a neutral radical from said plasma of the 1st gas has been arranged, and contains said neutral radical It has the gas supply plate with which two or more introductory holes which introduce into a substrate processing field the 2nd gas which forms the desired film in said deposited substrate were prepared between deposited substrates a plasma confinement electrode plate and said first half. Said gas supply plate is hollow structure, and the gaseous diffusion plate for equalizing the 2nd gas within a plate is formed in the interior. Plasma-CVD equipment characterized by the distance of the perpendicular direction of said gas supply plate and said deposited substrate being 1500 or less times of mean free path λ_{dag} at the time of the membrane formation in a substrate processing field.

[Claim 5] Plasma-CVD equipment according to claim 4 characterized by said gaseous diffusion plates being two or more diffusion plates located in parallel mutually in gas supply Sakauchi.

[Claim 6] The 1st process which forms the plasma of the 1st gas in a plasma production field, The 2nd process which shuts up said plasma with a plasma confinement electrode plate in said plasma production field, The 3rd

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process which supplies the 1st gas by which a plasma confinement electrode plate lets the arranged hole pass, and contains a neutral radical from said plasma between this plasma confinement electrode plate and a gas supply plate, The 4th process in which the 1st gas by which said gas supply plate contains a neutral radical from two or more arranged introductory holes is passed to a substrate processing field, and said gas supply plate with the gaseous diffusion plate which was formed in the interior and which equalizes the 2nd gas By the gaseous-phase chemical reaction of the 5th process which supplies the 2nd gas equalized to the substrate processing field in which a deposited substrate is installed, the 1st gas containing said neutral radical, and said 2nd gas The plasma-CVD membrane formation approach characterized by having the 6th process which forms the desired film in a deposited substrate, and the distance of the perpendicular direction of said gas supply plate and said deposited substrate having become 1500 or less times of mean free path λ at the time of the membrane formation in a substrate processing field.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the formation approach of the film precise to the remote plasma-CVD equipment which separates a plasma production field and a substrate processing field especially, and the large area homogeneity by remote plasma CVD about the plasma-CVD approach which used plasma-CVD equipment and this.

[0002]

[Description of the Prior Art] There is remote plasma-CVD equipment which divides a plasma production field and the substrate processing field R into one of the plasma-CVD equipment which performs film formation to a substrate controlling a plasma damage. Formation of the CVD film using this remote plasma equipment serves as a very important technique as a treatment process of thin film creation for producing a high-reliability device and a high performance device in a semiconductor device process.

[0003] As remote plasma-CVD equipment which can respond to large-sized substrates, such as a switching transistor formation process of a large area flat-panel display, a drive circuit transistor formation process, and a diameter silicon wafer process of macrostomia, parallel monotonous remote plasma-CVD equipment which is indicated by JP,5-21393,A, for example is indicated.

[0004] As the parallel monotonous mold remote plasma-CVD equipment in the remote plasma-CVD equipment of this conventional example is shown in drawing 7, the plasma confinement electrode 8 using the mesh plate which two or more holes opened is formed between the counterelectrodes 2 and the RF impression electrodes 1 with which a substrate 3 is installed in conventional parallel monotonous plasma-CVD equipment. And parallel monotonous mold remote plasma-CVD equipment shuts up the plasma 6 between this plasma confinement electrode 8 and the RF impression electrode 1. the large area shut up between the plasma confinement electrode 8 and the RF impression electrode 1 parallel being monotonous — substrate right above side internal division cloth, such as the neutral radical 4 supplied to the substrate processing field R from the uniform plasma 6 in order to supply gas, such as the neutral radical 4, to the substrate processing field R, — a large area — it becomes uniform and has the features that the thin film formation processing in a substrate 3 can carry out to homogeneity also to a large area substrate.

[0005] furthermore, generation processing of the film of on the process the inert gas nozzle 9 which injects inert gas 10 is formed near the hole 5 of a mesh plate, i.e., the passage hole of a radical 4, in the above-mentioned conventional example, and using the gaseous phase reaction of a radical 4 and inert gas 10, and as opposed to a substrate 3 — setting — a large area — uniform processing is possible.

[0006] namely, when the parallel monotonous remote plasma-CVD equipment shown in drawing 7 performs membrane formation (generation processing of a thin film) accompanied by a gaseous-phase chemical reaction in the substrate processing field R The plasma (plasma 6) of the 1st gas which contributes to a reaction is formed. The radical passage hole 5 of the plasma confinement electrode 8 from this plasma Through, It is made to react with the 2nd gas which supplies the radical (radical 4) of the 1st excited gas, and the 1st gas which is not excited to the substrate processing field R, and is supplied from the inert gas nozzle 9, and a membrane formation precursor required for thin film generation is formed.

[0007] For example, in performing silicon oxide membrane formation by the reaction of a mono silane (SiH_4) and oxygen (O_2), make the 1st gas into oxygen and let the 2nd gas be a mono silane. Since opening of many radical passage holes 5 and inert gas nozzles 9 is carried out to the plasma confinement electrode 8 at this time, if the 2nd gas (inert gas 10) is supplied to homogeneity from many inert gas nozzles 9, the above-mentioned gaseous

phase reaction in the substrate processing field R occurs in homogeneity in the right above side of a substrate 3, and can form the uniform film in the front face of a substrate 3.

[0008] Since it has mentioned above, promising ** of the parallel monotonous mold remote plasma-CVD equipment is carried out as an approach of forming the silicon oxide (SiO_2) film used as the gate dielectric film of a thin film transistor, a silicon nitride film (Si_3N_4 or Si_xN_y), the amorphous silicone film that similarly serves as a barrier layer of a thin film transistor, and a gate electrode on a large-sized glass substrate, the oxidation silicone film which serves as an interlayer insulation film of a transistor component on a large-sized Si substrate further, a silicon nitride film, etc. on a large-sized glass substrate.

[0009]

[Problem(s) to be Solved by the Invention] When the inert gas nozzle 9 tends to be formed near the radical passage hole 5 as mentioned above, and it is going to supply uniform inert gas 10 in a field from the inert gas nozzle 9, the plasma confinement electrode 8 of hollow structure will be used as indicated by the conventional example (JP,5-21393,A) mentioned above. In the plasma confinement electrode 8 of this hollow structure, as drawing 8 shuts up, an electrode side elevation and drawing 9 shut up and it is shown in an electrode plan, the radical passage hole 5 and the inert gas passage hole 9 are formed independently (dissociating) respectively, a radical 4 and inert gas 10 are mixed in a hollow field, and a radical 4 and inert gas 10 do not react in a hollow field.

[0010] As shown in drawing 9 or drawing 10, as an approach of supplying inert gas 10, the approach of supplying inert gas 10 in the hollow field of the plasma confinement electrode 8 from the inert gas installation tubing 12 formed in plasma confinement electrode 8 lateral portion is indicated by the plasma confinement electrode 8 of hollow structure in the conventional example here from the vacuum chamber exterior.

[0011] By the approach of this conventional example, the pressures in the centrum in the plasma confinement electrode 8 are the membrane formation pressure of the substrate processing field R, and comparable, i.e., dozens mTorr(s) – hundreds mTorr(s), and low voltage. for this reason, as typically shown in the conceptual diagram of drawing 11, a great portion of inert gas 10 will be injected from the inert gas nozzle 9 near the connection of the inert gas installation tubing 12 and the plasma confinement electrode 8, and only little inert gas 10 is injected from the nozzle 9 far from the inert gas installation tubing 12 — having — ** — it is ** and the fault that injection of uniform inert gas 10 will be difficult in a field is shown in the front face of a substrate 3.

[0012] Thus, what is necessary is just to lengthen distance D of the plasma confinement electrode 8 and substrate 3 which inject inert gas 10, in order for injection of uniform inert gas 10 to form the uniform film in substrate 3 front face in a field in a difficult situation in the field to a front face. That is, if the 2nd gas (inert gas 10) is supplied to the substrate processing field R at the ununiformity within a field and the 1st gas and gaseous-phase chemical reaction are caused, in the neighborhood to which the 2nd gas was supplied, the substrate 3 right above side internal division cloth of the resultant (membrane formation precursor) generated as a result of the gaseous-phase chemical reaction will also serve as an ununiformity.

[0013] However, since the time amount diffused in the parallel direction to substrate 3 front face will be enough given while the 2nd gas and resultant move even a substrate 3 if the above-mentioned distance D excels, when arriving at substrate 3 front face, the field internal division cloth in substrate 3 front face equalizes. In this membrane formation approach, to the width of face W of a CVD chamber, if the distance D of the plasma confinement electrode 8 and a substrate 3 is large, it will become easy to acquire an equalization operation.

[0014] For example, in forming membranes to a 500mmx600mm glass substrate, the width of face W of a CVD chamber is set to about 800mm, and if distance D13 of a plasma confinement electrode and a substrate is set to about 800mm of the same die length, an equalization operation will fully appear. However, it sets to membrane formation by the gaseous-phase chemical reaction. The plasma confinement electrode 8 with which the nozzle 9 which injects inert gas 10 as mentioned above was formed, If distance D with a deposited substrate (substrate 3) is lengthened, the gaseous phase reaction of the 1st gas and the 2nd gas containing a neutral radical will progress superfluously, and in the gaseous phase in the substrate processing field R the film generated since grain (membrane formation precursor) growth progressed and this grown-up grain accumulated on a deposited substrate front face — a non-dense — the problem of being easy to become dense arises.

[0015] For example, when performing silicon oxide membrane formation by the gaseous-phase chemical reaction of a mono silane and oxygen, a particle-like SiO_x grain (membrane formation precursor) will grow in the gaseous phase in the substrate processing field R. the non-dense generated as mentioned above — since defect density is high, it is large and leakage current becomes low also in withstand voltage, the dense film cannot be used for

the gate dielectric film of a thin film transistor etc.

[0016] This invention is to have been made under such a background and offer the remote plasma-CVD equipment and the remote plasma-CVD forming-membranes method for it being precise on a deposited substrate and being able to perform uniform film deposition in a field, without causing the grain growth by the superfluous gaseous-phase chemical reaction, which can supply a membrane formation precursor in membrane formation by the remote plasma-CVD approach by the gaseous-phase chemical reaction.

[0017]

[Means for Solving the Problem] It is characterized by to form the gaseous-diffusion plate for this invention being 1500 or less times of mean free path λ at the time of membrane formation [in / in the distance of the perpendicular direction of the plasma confinement electrode plate with which the introductory hole which introduces the 2nd gas into a substrate processing field has been arranged, and a deposited substrate / a substrate processing field], in order to attain the above-mentioned purpose, and said plasma-confinement electrode plate being hollow structure, and equalizing the 2nd gas within a plate. Since the 2nd gas is equalized within a plasma confinement electrode plate with a diffusion plate and it is introduced into a substrate processing field, The count of a chemical reaction is restricted. various base which the uniform gaseous-phase chemical reaction in a substrate right above side occurs, and happens after the 2nd gas is introduced into a substrate processing field before reaching a substrate — Since the grain growth by the gaseous phase by overresponse is controlled by satisfactory level, the uniform and precise film can be formed in a field on a deposited substrate. Moreover, the distance of the perpendicular direction of the gas supply plate which the introductory hole which introduces the 2nd gas into a substrate processing field is arranged in this invention, and is located between a plasma confinement electrode and a deposited substrate, and a deposited substrate It is characterized by forming the gaseous diffusion plate for being 1500 or less times of mean free path λ at the time of the membrane formation in a substrate processing field, and said gas supply plate being hollow structure, and equalizing the 2nd gas within a plate. Since the 2nd gas is equalized within a gas supply plate with a diffusion plate and it is introduced into a substrate processing field, The count of a chemical reaction is restricted. various base which the uniform gaseous-phase chemical reaction in a substrate right above side occurs, and happens after the 2nd gas is introduced into a substrate processing field before reaching a substrate — Since the grain growth by the gaseous phase by overresponse is controlled by satisfactory level, the uniform and precise film can be formed in a field on a deposited substrate.

[0018] The substrate processing field in which, as for invention according to claim 1, a deposited substrate is installed in plasma-CVD equipment, Separate the plasma production field which forms the plasma of the 1st gas, and said substrate processing field and plasma production field, and the plasma of said 1st gas is shut up. It is plasma-CVD equipment which has the plasma confinement electrode plate with which the hole which passes the 1st gas which contains a neutral radical from said plasma of the 1st gas has been arranged. Said plasma confinement electrode plate is hollow structure, and the gaseous diffusion plate for equalizing the 2nd gas within this plasma confinement electrode plate is formed in the interior. The 2nd gas which forms the desired film in said deposited substrate by the gaseous-phase chemical reaction with said neutral radical The introductory hole introduced into said substrate processing field is arranged at said plasma confinement electrode plate, and it is characterized by the distance of the perpendicular direction of said plasma confinement electrode plate and said deposited substrate being 1500 or less times of mean free path λ at the time of the membrane formation in a substrate processing field.

[0019] Invention according to claim 2 is characterized by said gaseous diffusion plates being two or more diffusion plates mutually located in parallel within a plasma confinement electrode in plasma-CVD equipment according to claim 1.

[0020] The 1st process in which invention according to claim 3 forms the plasma of the 1st gas in a plasma production field in the plasma-CVD membrane formation approach, The 2nd process which shuts up said plasma with a plasma confinement electrode plate in said plasma production field, The 3rd process in which the 1st gas by which a plasma confinement electrode plate lets the arranged hole pass, and contains a neutral radical from said plasma is passed to a substrate processing field, Said plasma confinement electrode plate with the gaseous diffusion plate which was formed in the interior and which equalizes the 2nd gas By the gaseous-phase chemical reaction of the 4th process which supplies the 2nd gas equalized to the substrate processing field in which a deposited substrate is installed, the 1st gas containing said neutral radical, and said 2nd gas It has the 5th process which forms the desired film in a deposited substrate, and is characterized by the distance of a perpendicular direction with a deposited substrate being 1500 or less times of mean free path λ at the

time of the membrane formation in a substrate processing field a plasma confinement electrode plate and said first half.

[0021] The substrate processing field in which, as for invention according to claim 4, a deposited substrate is installed in plasma-CVD equipment, Separate the plasma production field which forms the plasma of the 1st gas, and said substrate processing field and plasma production field, and the plasma of said 1st gas is shut up. By the gaseous-phase chemical reaction with the 1st gas which is plasma-CVD equipment which has the plasma confinement electrode plate with which the hole which passes the 1st gas which contains a neutral radical from said plasma of the 1st gas has been arranged, and contains said neutral radical It has the gas supply plate with which two or more introductory holes which introduce into a substrate processing field the 2nd gas which forms the desired film in said deposited substrate were prepared between said plasma confinement electrode plate and said deposited substrate. It is characterized by being hollow structure, forming the gaseous diffusion plate for equalizing the 2nd gas within a plate in the interior, and said gas supply plate having become 1500 or less times of mean free path λ at the time of membrane formation [in / in the distance of the perpendicular direction of said gas supply plate and a deposited substrate / a substrate processing field].

[0022] Invention according to claim 5 is characterized by said gaseous diffusion plates being two or more diffusion plates located in parallel mutually in gas supply Sakauchi in plasma-CVD equipment according to claim 4.

[0023] The 1st process in which invention according to claim 6 forms the plasma of the 1st gas in a plasma production field in the plasma-CVD membrane formation approach, The 2nd process which shuts up said plasma with a plasma confinement electrode plate in said plasma production field, The 3rd process which supplies the 1st gas by which a plasma confinement electrode plate lets the arranged hole pass, and contains a neutral radical from said plasma between this plasma confinement electrode plate and a gas supply plate, The 4th process in which the 1st gas by which said gas supply plate contains a neutral radical from two or more arranged introductory holes is passed to a substrate processing field, and said gas supply plate with the gaseous diffusion plate which was formed in the interior and which equalizes the 2nd gas By the gaseous-phase chemical reaction of the 5th process which supplies the 2nd gas equalized to the substrate processing field in which a deposited substrate is installed, the 1st gas containing said neutral radical, and said 2nd gas It has the 6th process which forms the desired film in a deposited substrate, and is characterized by the distance of the perpendicular direction of said gas supply plate and said deposited substrate being 1500 or less times of mean free path λ at the time of the membrane formation in a substrate processing field.

[0024]

[Embodiment of the Invention] Hereafter, the operation gestalt of this invention is explained with reference to a drawing. Drawing 1 is the conceptual diagram showing the cross section of the configuration of the remote plasma-CVD (chemical vapor growth) equipment by 1 operation gestalt of this invention. Oxidation silicone film formation [in / for 1 operation gestalt of this invention / the parallel monotonous remote plasma-CVD equipment of oxygen / silane system] is taken for an example, and it explains with reference to drawing below at a detail. About the same configuration as the conventional example, the same sign is attached and explanation of this configuration is omitted.

[0025] In this drawing parallel monotonous remote plasma-CVD equipment As fundamentally shown in drawing 1, the radical passage hole 5 and the inert gas nozzle 5 which pass the vacuum chamber in which evacuation is possible, RF generator 13, the high frequency impression electrode 1, the counterelectrode 2 that supports a substrate 3, and the gas containing a neutral radical (installation) are prepared. And it is constituted by the inert gas installation tubing 12 which is equipped with the plasma confinement electrode 20 grounded electrically, and introduces inert gas (for example, mono silane 19) from the side face of the plasma confinement electrode 20.

[0026] Moreover, the diffusion plate which has a radical passage hole and an inert gas nozzle prepares in the interior at the plasma confinement electrode 20, and it is *****. The cross-section schematic diagram of the plasma confinement electrode 20 which has this diffusion plate is shown in drawing 2. In this drawing, the 1st gaseous diffusion plate 23 and the 2nd gaseous diffusion plate 24 are formed, and are in the centrum inserted into the plasma confinement electrode up plate 26 and the plasma confinement electrode lower plate 27 (arranged)., two or more gaseous diffusion plates, i.e., 1 operation gestalt, for diffusing mono-silane gas (inert gas) 19 in homogeneity

[0027] In drawing 2, mono-silane gas 19 is supplied between the plasma confinement electrode up plate 26 and the 1st gaseous diffusion plate 23. Mono-silane gas 19 is equalized by hole 9A of the 1st gaseous diffusion plate 23. Furthermore it is equalized by hole 9B of the 2nd gaseous diffusion plate 24, and mono-silane gas 19 is

injected toward a substrate 3 by the homogeneity within a field from the inert gas nozzle 9 finally prepared in the plasma confinement electrode lower plate 27.

[0028] Here, it dissociates (becoming independent) and hole 9A, hole 9B and the inert gas nozzle 9, and the radical passage hole 5 are respectively formed in the plasma confinement electrode 20 so that an oxygen radical and the oxygen molecule 21, and mono-silane gas 19 may not be mixed. In order to perform the above-mentioned separation, the radical passage hole 5 is a connected hole which was formed with the wall isolated from the field where a mono silane exists, and has penetrated between the plasma confinement electrode up plate 26 and the plasma confinement electrode lower plates 27. In addition, although drawing 2 shows two diffusion plates of the 1st diffusion plate 23 and the 2nd diffusion plate 24, one sheet, two or more two sheets or more, or how many sheets are sufficient as this diffusion plate.

[0029] The opening aperture of the radical passage hole 5 penetrated between the plasma confinement electrode up plate 26 and the plasma confinement electrode lower plate 27 is set as the die length of 2 double less or equal extent of the Debye length of the plasma in the generated oxygen plasma 22 so that the generated oxygen plasma 22 can be shut up efficiently.

[0030] Next, drawing 3 shows the top view of the plasma confinement electrode up plate 26 and the plasma confinement electrode lower plate 27. Drawing 3 (a) shows the top view of the plasma confinement electrode up plate 26, and drawing 3 (b) shows the top view of the plasma confinement electrode lower plate 27.

[0031] Here, in drawing 3 (a), the radical passage hole 5 which passes the gas containing a neutral radical is punctured by predetermined spacing within the plate at homogeneity from the oxygen plasma 22 shut up by the plasma confinement electrode up plate 26. Moreover, in drawing 3 (b), from the oxygen plasma 22 shut up by the plasma confinement electrode lower plate 27, the radical passage hole 5 which passes the gas containing a neutral radical is punctured by predetermined spacing at the homogeneity in a plate, and the inert gas nozzle 9 is punctured by predetermined spacing in the location which is not in agreement with this radical passage hole 5 at the homogeneity in a plate.

[0032] Next, drawing 4 shows the top view of a gaseous diffusion plate (the 1st gaseous diffusion plate 23 and 2nd gaseous diffusion plate 24). Here, two above-mentioned gaseous diffusion plates, the 1st gaseous diffusion plate 23, and the 2nd gaseous diffusion plate 24 are equivalent to the 1st gaseous diffusion plate 23 of drawing 2, and the 2nd gaseous diffusion plate 24.

[0033] In drawing 4 (a), the radical passage hole 5 which passes the gas which contains a neutral radical in the 1st gaseous diffusion plate 23 is punctured by predetermined spacing within a plate at homogeneity, and the inert gas passage hole 9 is punctured by homogeneity in the location which is not in agreement with the radical passage hole 5 of the predetermined field Q near a core. Moreover, in drawing 4 (b), the radical passage hole 5 which passes the gas which contains a neutral radical in the 2nd gaseous diffusion plate 24 is punctured by predetermined spacing within a plate at homogeneity, and the inert gas passage hole 9 is punctured by homogeneity in the location which is not in agreement with the radical passage hole 5 of the predetermined field P near a core.

[0034] Here, Field P shows a field larger than Field Q in plane view, including the above-mentioned field Q, when installing the 1st gaseous diffusion plate 23 and the 2nd gaseous diffusion plate 24 in the plasma confinement electrode 20 and these two diffusion plates are piled up. That is, the inert gas passage hole 9 is not only punctured by the puncturing location in the 1st gaseous diffusion plate 23, and the same location, but in the 2nd gaseous diffusion plate 24, the inert gas passage hole 9 is further punctured by the periphery field.

[0035] On the whole surface in a diffusion plate, although opening of the hole of inert gas passage may be carried out to homogeneity, as mentioned above By devising the location of the hole of the diffusion plate which plurality piles up as shown in drawing 4 As shown in drawing 11, it can prevent a lot of gas being injected by the substrate processing field R in the inert gas installation tubing 12 neighborhood, and uniform inert gas (for example, mono-silane gas 19 grade) can be supplied more in a field to the front face of a substrate 3.

[0036] moreover, in the configuration of a diffusion plate, when installing the 1st gaseous diffusion plate 23 and the 2nd gaseous diffusion plate 24 in the plasma confinement electrode 20 and these two diffusion plates are piled up, the configuration which forms the mono-silane gas (inert gas) 19 of two or more diffusion plates so that the hole to pour, i.e., hole 9A, and hole 9B may not lap in plane view (it is not located on a straight line — as) is also possible.

[0037] Next, with reference to drawing 1, drawing 2, drawing 3, and drawing 4, the formation approach of the oxidation silicone film to substrate 3 front face by the remote plasma-CVD equipment by 1 operation gestalt of this invention is explained below. Within the CVD chamber in an evacuation condition (it has a predetermined

pressure) Introduce oxygen gas 18 into the RF impression electrode 1, and this oxygen gas 18 is supplied in the direction of the plasma confinement electrode 20 from the inferior surface of tongue of the RF impression electrode 1 at homogeneity. Glow discharge is made to start from RF generator 13 by the RF supplied to the RF impression electrode 1 between the plasma confinement electrodes 20 which have a diffusion plate (the 1st gaseous diffusion plate 23 and the 2nd diffusion plate 24 which are shown in drawing 4).

[0038] The oxygen plasma 22 generated by this glow discharge is efficiently shut up between the RF impression electrode 1 and the plasma confinement electrode 20. The plasma consistency between the plasma confinement electrode 20 and a counterelectrode 2 (or substrate 3) has become about [105cm - 3-106cm -] three to the plasma consistency in the result 22, for example, the oxygen plasma, being about [1010cm -] three.

[0039] That is, although an electron, oxygen atom ion, oxygen molecular ion, an oxygen atom radical, an oxygen molecule radical, and an oxygen molecule exist in the oxygen plasma 22, it is shown that the electron and ion which invade out of the plasma are the amount of extent which can be disregarded. Therefore, what it reacts with the mono-silane gas 19 injected by the substrate processing field R besides the oxygen plasma 22, and is contributed to silicon oxide film membrane formation is an oxygen atom radical, an oxygen molecule radical, and an oxygen molecule that is not excited.

[0040] And an oxygen radical and the oxygen molecule 21 are diffused to the substrate processing field R through the radical passage hole 5, and the mono-silane gas 19 and the gaseous-phase chemical reaction which were injected from the inert gas nozzle 9 are caused. Of this gaseous-phase chemical reaction, silicon oxide precursors (membrane formation precursor), such as SiOx, SiOxHy, and SiHy, are formed, and when this formed silicon oxide precursor accumulates on substrate 3 front face, an oxidation silicone film is formed in substrate 3 front face.

[0041] The distance D of the plasma confinement electrode 20 and a substrate 3 (vertical distance) is set up here so that it may become 1500 or less (however, number exceeding "0") times of average free process lambdag of the oxygen (the oxygen radical and oxygen molecule 21) / mono-silane mixed gas in the substrate processing field R. Since it has controlled that a gaseous-phase chemical reaction progresses superfluously with this distance D, when oxidation silicone film precursors, such as SiOx, SiOxHy, and SiHy, carry out grain growth by the gaseous phase in the substrate processing field R, it does not grow up to be particle-like magnitude.

[0042] For example, what is necessary is just to set distance D of a plasma confinement electrode and a substrate to 90mm or less in the gas temperature of 300 degrees C, and chamber pressure 250mTorr, since average free process lambdag of oxygen / mono-silane mixed gas is about 60 micrometers. The leak current characteristic when using as the gate dielectric film of an MOS (metal, oxide-film, and semi-conductor) capacitor the oxidation silicone film which actually formed membranes as an example which formed the oxidation silicone film on condition that the substrate temperature of 300 degrees C, substrate processing field R pressure 250mTorr, oxygen flow rate 800sccm supplied to a plasma field through the RF impression electrode 1, and mono-silane quantity-of-gas-flow 5sccm supplied to the inert gas installation tubing 12 is shown in drawing 5 .

[0043] In drawing 5 , the leak current density value has changed a lot by the case where distance D of the plasma confinement electrode 20 and a substrate 3 is set to 300mm, and the case where it is made 60mm. That is, the leak current characteristic of the film which formed the distance D of the plasma confinement electrode 20 and a substrate 3 as 60mm has near, the electric insulating property [it is good and] which can be used as gate dielectric film and the interlayer insulation film of a thin film transistor, and pressure-proofing in the current characteristic of the silicon thermal oxidation film.

[0044] On the other hand, big leakage current is flowing from the low electric-field field, the leak current characteristic of the film which formed the distance D of the plasma confinement electrode 20 and a substrate 3 as 300mm has an electric insulating property and low pressure-proofing to gate dielectric film and the interlayer insulation film of a thin film transistor, and they cannot use it for them.

[0045] In the experiment conditions mentioned above, average free process lambdag of the oxygen / mono-silane mixed gas in the substrate processing field R is about 60 micrometers. At this time, it corresponds by about 5000 times the above-mentioned average free process lambdag the distance D of an electric insulating property and the plasma confinement electrode 20 with lower pressure-proofing, and a substrate 3, i.e., 300mm.

[0046] On the other hand, it corresponds by about 1000 times the above-mentioned average free process lambdag the distance D of an electric insulating property and the plasma confinement electrode 20 with lower pressure-proofing, and a substrate 3, i.e., 60mm. If the distance D of the plasma confinement electrode 20 and a substrate 3 is 5000 times as large as the above-mentioned average free process lambdag, the gaseous-phase chemical reaction of an oxygen radical and the oxygen molecule 21, and mono-silane gas 19 will progress too

much, the particle which carried out grain growth in the gaseous phase in the substrate processing field R will accumulate on substrate 3 front face as film, and it will be guessed that the roughness and fineness film has been formed in substrate 3 front face.

[0047] On the other hand, if it is the distance D of the about 1000 times [of the above-mentioned average free process λ_{dag}] plasma confinement electrode 20, and a substrate 3, the gaseous-phase chemical reaction of an oxygen radical and the oxygen molecule 21, and mono-silane gas 19 will not progress too much, grain growth in a gaseous phase will be restricted, and it will be guessed that a particle-like oxidation silicone film precursor does not accumulate as film in substrate 3 front face.

[0048] Moreover, as mentioned above, since the plasma consistency between the plasma confinement electrode 20 and a counterelectrode 2 is very low, compared with the usual parallel monotonous plasma CVD, the plasma damage to a substrate 3 is stopped very low.

[0049] To the case on the front face of silicon in which the front face of a substrate 3 forms an MOS interface, this effectiveness When it appears notably and SiO₂ film is formed on a single crystal silicon substrate by the usual parallel monotonous plasma CVD When an oxidation silicone film is formed by parallel monotonous remote plasma CVD to the MOS interface-state-density consistency being 10¹¹-10¹²cm⁻²eV⁻¹ near a mid gap, it becomes an about [-10¹⁰cm⁻²eV⁻¹] low interface-state-density consistency.

[0050] As mentioned above, although 1 operation gestalt of this invention has been explained in full detail with reference to a drawing, a concrete configuration is not restricted to this operation gestalt, and even if the design change of the range which does not deviate from the summary of this invention etc. occurs, it is included in this invention. For example, the parallel monotonous remote plasma CVD by the 2nd operation gestalt is explained using drawing 6. Drawing 6 is the conceptual diagram showing the cross section of the configuration of parallel monotonous mold remote plasma-CVD equipment. About the same configuration as the conventional example and 1 operation gestalt, the same sign is attached and explanation of this configuration is omitted.

[0051] In this drawing, the parallel monotonous mold remote plasma-CVD equipment of drawing 6 differing from the parallel monotonous remote plasma-CVD equipment of drawing 1 is that the gas supply plate 29 which the inert gas installation tubing 12 is connected, introduces inert gas (mono-silane gas 19) into it, equalizes gas concentration with the gaseous diffusion plate formed in the interior, and is injected to a substrate side does not have the function of plasma confinement.

[0052] For this reason, that aperture is arbitrary if homogeneity injection of a radical 4 is possible for the radical passage hole 5 of the gas supply plate 29 which has a diffusion plate. Moreover, it is also possible to use it in the state of electric suspension, without grounding electrically. That is, although the gas supply plate 29 of the configuration itself is the same as that of the plasma confinement electrode 20 in 1 operation gestalt, the apertures of the point and radical passage hole which are not grounded differ.

[0053] In addition, this gas supply plate 29 is located between the plasma confinement electrode 8 and a counterelectrode 2, and it is set up so that the distance F of the gas supply plate 29 and a substrate 3 may become 1500 or less (however, number exceeding "0") times of average free process λ_{dag} of the oxygen (the oxygen radical and oxygen molecule 21) / mono-silane mixed gas in the substrate processing field R.

[0054] Except the above, it has the structure where the plasma confinement electrode 20 which has the gas supply plate 29 which has a diffusion plate in the 2nd operation gestalt, and a diffusion plate in 1 operation gestalt is the same. Moreover, the view about the relation of distribution of the hole which passes the radical passage hole and inert gas in the structure of the gaseous diffusion plate in the gas supply plate 29 and the number of gaseous diffusion plates, and a gaseous diffusion plate etc. is the same as that of the gaseous diffusion plate (the 1st gaseous diffusion plate and 2nd gaseous diffusion plate) formed in the plasma confinement electrode 20 in 1 operation gestalt.

[0055] Moreover, it is the same as that of the view about the distance D of the plasma confinement electrode 20 and substrate 3 in 1 operation gestalt, an oxygen radical and the oxygen molecule 21, and the gaseous-phase chemical reaction of mono-silane gas 19 do not progress too much, grain growth in a gaseous phase is restricted, and particle does not deposit the view over the distance F of the gas supply plate 29 and a substrate 3 on the front face of a substrate 3 as film, either.

[0056] In the above 1 operation gestalt and the 2nd operation gestalt, although the silicon oxide film formation using a mono silane and oxygen was mentioned as the example and this invention was explained, liquid Si raw materials, such as high order silanes, such as a disilane, and TEOS (Tetraethoxysilane), etc. are sufficient instead of a mono silane, and nitrous oxide, nitrogen oxide, etc. may be used instead of oxygen.

[0057] Moreover, although explained by the remote plasma-CVD equipment in 1 operation gestalt and the 2nd

operation gestalt which were mentioned above mentioning oxidation silicon film formation as an example Even if it uses the silicon nitride film formation by the reaction of a mono silane and ammonia etc. for the plasma-CVD membrane formation accompanied by the gaseous-phase chemical reaction of other ingredient systems, the same effectiveness as the film generated with 1 operation gestalt and the 2nd operation gestalt can be acquired to the generated film.

[0058] Furthermore, although the example using parallel monotonous remote plasma-CVD equipment was given in the gestalt of the above operation, this invention will be applied, even if it is equipments of what kind of gestalt, such as plasma-CVD equipment using the microwave plasma, the electron cyclotron resonance plasma, inductively coupled plasma, and the helicon wave plasma, if it is plasma-CVD equipment with which two or more holes were prepared between the plasma production field and the substrate processing field R and which has a plasma confinement electrode for plasma separation.

[0059]

[Effect of the Invention] According to the remote plasma-CVD equipment of this invention, in the remote plasma CVD which forms membranes by the gaseous-phase chemical reaction, concentration of the inert gas which can control a superfluous advance of a gaseous-phase chemical reaction, and is injected out of a plasma field can be made into homogeneity on a deposited substrate. Therefore, according to the remote plasma-CVD equipment of this invention, in case gate dielectric film and the interlayer insulation film of a MOS device are produced, the precise film which does not contain particle etc. can be formed in a large area substrate at homogeneity.

[Translation done.]

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TECHNICAL FIELD

[Field of the Invention] This invention relates to the formation approach of the film precise to the remote plasma-CVD equipment which separates a plasma production field and a substrate processing field especially, and the large area homogeneity by remote plasma CVD about the plasma-CVD approach which used plasma-CVD equipment and this.

[Translation done.]

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PRIOR ART

[Description of the Prior Art] There is remote plasma-CVD equipment which divides a plasma production field and the substrate processing field R into one of the plasma-CVD equipment which performs film formation to a substrate controlling a plasma damage. Formation of the CVD film using this remote plasma equipment serves as a very important technique as a treatment process of thin film creation for producing a high-reliability device and a high performance device in a semiconductor device process.

[0003] As remote plasma-CVD equipment which can respond to large-sized substrates, such as a switching transistor formation process of a large area flat-panel display, a drive circuit transistor formation process, and a diameter silicon wafer process of macrostomia, parallel monotonous remote plasma-CVD equipment which is indicated by JP,5-21393,A, for example is indicated.

[0004] As the parallel monotonous mold remote plasma-CVD equipment in the remote plasma-CVD equipment of this conventional example is shown in drawing 7, the plasma confinement electrode 8 using the mesh plate which two or more holes opened is formed between the counterelectrodes 2 and the RF impression electrodes 1 with which a substrate 3 is installed in conventional parallel monotonous plasma-CVD equipment. And parallel monotonous mold remote plasma-CVD equipment shuts up the plasma 6 between this plasma confinement electrode 8 and the RF impression electrode 1. the large area shut up between the plasma confinement electrode 8 and the RF impression electrode 1 parallel being monotonous -- substrate right above side internal division cloth, such as the neutral radical 4 supplied to the substrate processing field R from the uniform plasma 6 in order to supply gas, such as the neutral radical 4, to the substrate processing field R, -- a large area -- it becomes uniform and has the features that the thin film formation processing in a substrate 3 can carry out to homogeneity also to a large area substrate.

[0005] furthermore, generation processing of the film of on the process the inert gas nozzle 9 which injects inert gas 10 is formed near the hole 5 of a mesh plate, i.e., the passage hole of a radical 4, in the above-mentioned conventional example, and using the gaseous phase reaction of a radical 4 and inert gas 10, and as opposed to a substrate 3 -- setting -- a large area -- uniform processing is possible.

[0006] namely, when the parallel monotonous remote plasma-CVD equipment shown in drawing 7 performs membrane formation (generation processing of a thin film) accompanied by a gaseous-phase chemical reaction in the substrate processing field R The plasma (plasma 6) of the 1st gas which contributes to a reaction is formed. The radical passage hole 5 of the plasma confinement electrode 8 from this plasma Through, It is made to react with the 2nd gas which supplies the radical (radical 4) of the 1st excited gas, and the 1st gas which is not excited to the substrate processing field R, and is supplied from the inert gas nozzle 9, and a membrane formation precursor required for thin film generation is formed.

[0007] For example, in performing silicon oxide membrane formation by the reaction of a mono silane (SiH_4) and oxygen (O_2), make the 1st gas into oxygen and let the 2nd gas be a mono silane. Since opening of many radical passage holes 5 and inert gas nozzles 9 is carried out to the plasma confinement electrode 8 at this time, if the 2nd gas (inert gas 10) is supplied to homogeneity from many inert gas nozzles 9, the above-mentioned gaseous phase reaction in the substrate processing field R occurs in homogeneity in the right above side of a substrate 3, and can form the uniform film in the front face of a substrate 3.

[0008] Since it has mentioned above, promising ** of the parallel monotonous mold remote plasma-CVD equipment is carried out as an approach of forming the silicon oxide (SiO_2) film used as the gate dielectric film of a thin film transistor, a silicon nitride film (Si_3N_4 or SixNy), the amorphous silicone film that similarly serves as a barrier layer of a thin film transistor, and a gate electrode on a large-sized glass substrate, the oxidation silicone film which serves as an interlayer insulation film of a transistor component on a large-sized Si substrate

further, a silicon nitride film, etc. on a large-sized glass substrate.

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EFFECT OF THE INVENTION

[Effect of the Invention] According to the remote plasma-CVD equipment of this invention, in the remote plasma CVD which forms membranes by the gaseous-phase chemical reaction, concentration of the inert gas which can control a superfluous advance of a gaseous-phase chemical reaction, and is injected out of a plasma field can be made into homogeneity on a deposited substrate. Therefore, according to the remote plasma-CVD equipment of this invention, in case gate dielectric film and the interlayer insulation film of a MOS device are produced, the precise film which does not contain particle etc. can be formed in a large area substrate at homogeneity.

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TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] When the inert gas nozzle 9 tends to be formed near the radical passage hole 5 as mentioned above, and it is going to supply uniform inert gas 10 in a field from the inert gas nozzle 9, the plasma confinement electrode 8 of hollow structure will be used as indicated by the conventional example (JP,5-21393,A) mentioned above. In the plasma confinement electrode 8 of this hollow structure, as drawing 8 shuts up, an electrode side elevation and drawing 9 shut up and it is shown in an electrode plan, the radical passage hole 5 and the inert gas passage hole 9 are formed independently (dissociating) respectively, a radical 4 and inert gas 10 are mixed in a hollow field, and a radical 4 and inert gas 10 do not react in a hollow field.

[0010] As shown in drawing 9 or drawing 10 , as an approach of supplying inert gas 10, the approach of supplying inert gas 10 in the hollow field of the plasma confinement electrode 8 from the inert gas installation tubing 12 formed in plasma confinement electrode 8 lateral portion is indicated by the plasma confinement electrode 8 of hollow structure in the conventional example here from the vacuum chamber exterior.

[0011] By the approach of this conventional example, the pressures in the centrum in the plasma confinement electrode 8 are the membrane formation pressure of the substrate processing field R, and comparable, i.e., dozens mTorr(s) - hundreds mTorr(s), and low voltage. for this reason, as typically shown in the conceptual diagram of drawing 11 , a great portion of inert gas 10 will be injected from the inert gas nozzle 9 near the connection of the inert gas installation tubing 12 and the plasma confinement electrode 8, and only little inert gas 10 is injected from the nozzle 9 far from the inert gas installation tubing 12 — having — ** — it is ** and the fault that injection of uniform inert gas 10 will be difficult in a field is shown in the front face of a substrate 3.

[0012] Thus, what is necessary is just to lengthen distance D of the plasma confinement electrode 8 and substrate 3 which inject inert gas 10, in order for injection of uniform inert gas 10 to form the uniform film in substrate 3 front face in a field in a difficult situation in the field to a front face. That is, if the 2nd gas (inert gas 10) is supplied to the substrate processing field R at the ununiformity within a field and the 1st gas and gaseous-phase chemical reaction are caused, in the neighborhood to which the 2nd gas was supplied, the substrate 3 right above side internal division cloth of the resultant (membrane formation precursor) generated as a result of the gaseous-phase chemical reaction will also serve as an ununiformity.

[0013] However, since the time amount diffused in the parallel direction to substrate 3 front face will be enough given while the 2nd gas and resultant move even a substrate 3 if the above-mentioned distance D excels, when arriving at substrate 3 front face, the field internal division cloth in substrate 3 front face equalizes. In this membrane formation approach, to the width of face W of a CVD chamber, if the distance D of the plasma confinement electrode 8 and a substrate 3 is large, it will become easy to acquire an equalization operation.

[0014] For example, in forming membranes to a 500mmx600mm glass substrate, the width of face W of a CVD chamber is set to about 800mm, and if distance D13 of a plasma confinement electrode and a substrate is set to about 800mm of the same die length, an equalization operation will fully appear. However, it sets to membrane formation by the gaseous-phase chemical reaction. The plasma confinement electrode 8 with which the nozzle 9 which injects inert gas 10 as mentioned above was formed, If distance D with a deposited substrate (substrate 3) is lengthened, the gaseous phase reaction of the 1st gas and the 2nd gas containing a neutral radical will progress superfluously, and in the gaseous phase in the substrate processing field R the film generated since grain (membrane formation precursor) growth progressed and this grown-up grain accumulated on a deposited substrate front face — a non-dense — the problem of being easy to become dense arises.

[0015] For example, when performing silicon oxide membrane formation by the gaseous-phase chemical reaction

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of a mono silane and oxygen, a particle-like SiO_x grain (membrane formation precursor) will grow in the gaseous phase in the substrate processing field R. the non-dense generated as mentioned above — since defect density is high, it is large and leakage current becomes low also in withstand voltage, the dense film cannot be used for the gate dielectric film of a thin film transistor etc.

[0016] This invention is to have been made under such a background and offer the remote plasma-CVD equipment and the remote plasma-CVD forming-membranes method for it being precise on a deposited substrate and being able to perform uniform film deposition in a field, without causing the grain growth by the superfluous gaseous-phase chemical reaction, which can supply a membrane formation precursor in membrane formation by the remote plasma-CVD approach by the gaseous-phase chemical reaction.

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MEANS

[Means for Solving the Problem] It is characterized by to form the gaseous-diffusion plate for this invention being 1500 or less times of mean free path λ at the time of membrane formation [in / in the distance of the perpendicular direction of the plasma confinement electrode plate with which the introductory hole which introduces the 2nd gas into a substrate processing field has been arranged, and a deposited substrate / a substrate processing field], in order to attain the above-mentioned purpose, and said plasma-confinement electrode plate being hollow structure, and equalizing the 2nd gas within a plate. Since the 2nd gas is equalized within a plasma confinement electrode plate with a diffusion plate and it is introduced into a substrate processing field, The count of a chemical reaction is restricted. various base which the uniform gaseous-phase chemical reaction in a substrate right above side occurs, and happens after the 2nd gas is introduced into a substrate processing field before reaching a substrate — Since the grain growth by the gaseous phase by overresponse is controlled by satisfactory level, the uniform and precise film can be formed in a field on a deposited substrate. Moreover, the distance of the perpendicular direction of the gas supply plate which the introductory hole which introduces the 2nd gas into a substrate processing field is arranged in this invention, and is located between a plasma confinement electrode and a deposited substrate, and a deposited substrate It is characterized by forming the gaseous diffusion plate for being 1500 or less times of mean free path λ at the time of the membrane formation in a substrate processing field, and said gas supply plate being hollow structure, and equalizing the 2nd gas within a plate. Since the 2nd gas is equalized within a gas supply plate with a diffusion plate and it is introduced into a substrate processing field, The count of a chemical reaction is restricted. various base which the uniform gaseous-phase chemical reaction in a substrate right above side occurs, and happens after the 2nd gas is introduced into a substrate processing field before reaching a substrate — Since the grain growth by the gaseous phase by overresponse is controlled by satisfactory level, the uniform and precise film can be formed in a field on a deposited substrate.

[0018] The substrate processing field in which, as for invention according to claim 1, a deposited substrate is installed in plasma-CVD equipment, Separate the plasma production field which forms the plasma of the 1st gas, and said substrate processing field and plasma production field, and the plasma of said 1st gas is shut up. It is plasma-CVD equipment which has the plasma confinement electrode plate with which the hole which passes the 1st gas which contains a neutral radical from said plasma of the 1st gas has been arranged. Said plasma confinement electrode plate is hollow structure, and the gaseous diffusion plate for equalizing the 2nd gas within this plasma confinement electrode plate is formed in the interior. The 2nd gas which forms the desired film in said deposited substrate by the gaseous-phase chemical reaction with said neutral radical The introductory hole introduced into said substrate processing field is arranged at said plasma confinement electrode plate, and it is characterized by the distance of the perpendicular direction of said plasma confinement electrode plate and said deposited substrate being 1500 or less times of mean free path λ at the time of the membrane formation in a substrate processing field.

[0019] Invention according to claim 2 is characterized by said gaseous diffusion plates being two or more diffusion plates mutually located in parallel within a plasma confinement electrode in plasma-CVD equipment according to claim 1.

[0020] The 1st process in which invention according to claim 3 forms the plasma of the 1st gas in a plasma production field in the plasma-CVD membrane formation approach, The 2nd process which shuts up said plasma with a plasma confinement electrode plate in said plasma production field, The 3rd process in which the 1st gas by which a plasma confinement electrode plate lets the arranged hole pass, and contains a neutral radical from said plasma is passed to a substrate processing field, Said plasma confinement electrode plate with the gaseous

diffusion plate which was formed in the interior and which equalizes the 2nd gas By the gaseous-phase chemical reaction of the 4th process which supplies the 2nd gas equalized to the substrate processing field in which a deposited substrate is installed, the 1st gas containing said neutral radical, and said 2nd gas It has the 5th process which forms the desired film in a deposited substrate, and is characterized by the distance of a perpendicular direction with a deposited substrate being 1500 or less times of mean free path λ at the time of the membrane formation in a substrate processing field a plasma confinement electrode plate and said first half.

[0021] The substrate processing field in which, as for invention according to claim 4, a deposited substrate is installed in plasma-CVD equipment, Separate the plasma production field which forms the plasma of the 1st gas, and said substrate processing field and plasma production field, and the plasma of said 1st gas is shut up. By the gaseous-phase chemical reaction with the 1st gas which is plasma-CVD equipment which has the plasma confinement electrode plate with which the hole which passes the 1st gas which contains a neutral radical from said plasma of the 1st gas has been arranged, and contains said neutral radical It has the gas supply plate with which two or more introductory holes which introduce into a substrate processing field the 2nd gas which forms the desired film in said deposited substrate were prepared between said plasma confinement electrode plate and said deposited substrate. It is characterized by being hollow structure, forming the gaseous diffusion plate for equalizing the 2nd gas within a plate in the interior, and said gas supply plate having become 1500 or less times of mean free path λ at the time of membrane formation [in / in the distance of the perpendicular direction of said gas supply plate and a deposited substrate / a substrate processing field].

[0022] Invention according to claim 5 is characterized by said gaseous diffusion plates being two or more diffusion plates located in parallel mutually in gas supply Sakauchi in plasma-CVD equipment according to claim 4.

[0023] The 1st process in which invention according to claim 6 forms the plasma of the 1st gas in a plasma production field in the plasma-CVD membrane formation approach, The 2nd process which shuts up said plasma with a plasma confinement electrode plate in said plasma production field, The 3rd process which supplies the 1st gas by which a plasma confinement electrode plate lets the arranged hole pass, and contains a neutral radical from said plasma between this plasma confinement electrode plate and a gas supply plate, The 4th process in which the 1st gas by which said gas supply plate contains a neutral radical from two or more arranged introductory holes is passed to a substrate processing field, and said gas supply plate with the gaseous diffusion plate which was formed in the interior and which equalizes the 2nd gas By the gaseous-phase chemical reaction of the 5th process which supplies the 2nd gas equalized to the substrate processing field in which a deposited substrate is installed, the 1st gas containing said neutral radical, and said 2nd gas It has the 6th process which forms the desired film in a deposited substrate, and is characterized by the distance of the perpendicular direction of said gas supply plate and said deposited substrate being 1500 or less times of mean free path λ at the time of the membrane formation in a substrate processing field.

[0024]

[Embodiment of the Invention] Hereafter, the operation gestalt of this invention is explained with reference to a drawing. Drawing 1 is the conceptual diagram showing the cross section of the configuration of the remote plasma-CVD (chemical vapor growth) equipment by 1 operation gestalt of this invention. Oxidation silicone film formation [in / for 1 operation gestalt of this invention / the parallel monotonous remote plasma-CVD equipment of oxygen / silane system] is taken for an example, and it explains with reference to drawing below at a detail. About the same configuration as the conventional example, the same sign is attached and explanation of this configuration is omitted.

[0025] In this drawing parallel monotonous remote plasma-CVD equipment As fundamentally shown in drawing 1, the radical passage hole 5 and the inert gas nozzle 5 which pass the vacuum chamber in which evacuation is possible, RF generator 13, the high frequency impression electrode 1, the counterelectrode 2 that supports a substrate 3, and the gas containing a neutral radical (installation) are prepared. And it is constituted by the inert gas installation tubing 12 which is equipped with the plasma confinement electrode 20 grounded electrically, and introduces inert gas (for example, mono silane 19) from the side face of the plasma confinement electrode 20.

[0026] Moreover, the diffusion plate which has a radical passage hole and an inert gas nozzle prepares in the interior at the plasma confinement electrode 20, and it is *****. The cross-section schematic diagram of the plasma confinement electrode 20 which has this diffusion plate is shown in drawing 2. In this drawing, the 1st gaseous diffusion plate 23 and the 2nd gaseous diffusion plate 24 are formed, and are in the centrum inserted into the plasma confinement electrode up plate 26 and the plasma confinement electrode lower plate 27

(arranged), two or more gaseous diffusion plates, i.e., 1 operation gestalt, for diffusing mono-silane gas (inert gas) 19 in homogeneity

[0027] In drawing 2, mono-silane gas 19 is supplied between the plasma confinement electrode up plate 26 and the 1st gaseous diffusion plate 23. Mono-silane gas 19 is equalized by hole 9A of the 1st gaseous diffusion plate 23. Furthermore it is equalized by hole 9B of the 2nd gaseous diffusion plate 24, and mono-silane gas 19 is injected toward a substrate 3 by the homogeneity within a field from the inert gas nozzle 9 finally prepared in the plasma confinement electrode lower plate 27.

[0028] Here, it dissociates (becoming independent) and hole 9A, hole 9B and the inert gas nozzle 9, and the radical passage hole 5 are respectively formed in the plasma confinement electrode 20 so that an oxygen radical and the oxygen molecule 21, and mono-silane gas 19 may not be mixed. In order to perform the above-mentioned separation, the radical passage hole 5 is a connected hole which was formed with the wall isolated from the field where a mono silane exists, and has penetrated between the plasma confinement electrode up plate 26 and the plasma confinement electrode lower plates 27. In addition, although drawing 2 shows two diffusion plates of the 1st diffusion plate 23 and the 2nd diffusion plate 24, one sheet, two or more two sheets or more, or how many sheets are sufficient as this diffusion plate.

[0029] The opening aperture of the radical passage hole 5 penetrated between the plasma confinement electrode up plate 26 and the plasma confinement electrode lower plate 27 is set as the die length of 2 double less or equal extent of the Debye length of the plasma in the generated oxygen plasma 22 so that the generated oxygen plasma 22 can be shut up efficiently.

[0030] Next, drawing 3 shows the top view of the plasma confinement electrode up plate 26 and the plasma confinement electrode lower plate 27. Drawing 3 (a) shows the top view of the plasma confinement electrode up plate 26, and drawing 3 (b) shows the top view of the plasma confinement electrode lower plate 27.

[0031] Here, in drawing 3 (a), the radical passage hole 5 which passes the gas containing a neutral radical is punctured by predetermined spacing within the plate at homogeneity from the oxygen plasma 22 shut up by the plasma confinement electrode up plate 26. Moreover, in drawing 3 (b), from the oxygen plasma 22 shut up by the plasma confinement electrode lower plate 27, the radical passage hole 5 which passes the gas containing a neutral radical is punctured by predetermined spacing at the homogeneity in a plate, and the inert gas nozzle 9 is punctured by predetermined spacing in the location which is not in agreement with this radical passage hole 5 at the homogeneity in a plate.

[0032] Next, drawing 4 shows the top view of a gaseous diffusion plate (the 1st gaseous diffusion plate 23 and 2nd gaseous diffusion plate 24). Here, two above-mentioned gaseous diffusion plates, the 1st gaseous diffusion plate 23, and the 2nd gaseous diffusion plate 24 are equivalent to the 1st gaseous diffusion plate 23 of drawing 2, and the 2nd gaseous diffusion plate 24.

[0033] In drawing 4 (a), the radical passage hole 5 which passes the gas which contains a neutral radical in the 1st gaseous diffusion plate 23 is punctured by predetermined spacing within a plate at homogeneity, and the inert gas passage hole 9 is punctured by homogeneity in the location which is not in agreement with the radical passage hole 5 of the predetermined field Q near a core. Moreover, in drawing 4 (b), the radical passage hole 5 which passes the gas which contains a neutral radical in the 2nd gaseous diffusion plate 24 is punctured by predetermined spacing within a plate at homogeneity, and the inert gas passage hole 9 is punctured by homogeneity in the location which is not in agreement with the radical passage hole 5 of the predetermined field P near a core.

[0034] Here, Field P shows a field larger than Field Q in plane view, including the above-mentioned field Q, when installing the 1st gaseous diffusion plate 23 and the 2nd gaseous diffusion plate 24 in the plasma confinement electrode 20 and these two diffusion plates are piled up. That is, the inert gas passage hole 9 is not only punctured by the puncturing location in the 1st gaseous diffusion plate 23, and the same location, but in the 2nd gaseous diffusion plate 24, the inert gas passage hole 9 is further punctured by the periphery field.

[0035] On the whole surface in a diffusion plate, although opening of the hole of inert gas passage may be carried out to homogeneity, as mentioned above By devising the location of the hole of the diffusion plate which plurality piles up as shown in drawing 4 As shown in drawing 11, it can prevent a lot of gas being injected by the substrate processing field R in the inert gas installation tubing 12 neighborhood, and uniform inert gas (for example, mono-silane gas 19 grade) can be supplied more in a field to the front face of a substrate 3.

[0036] moreover, in the configuration of a diffusion plate, when installing the 1st gaseous diffusion plate 23 and the 2nd gaseous diffusion plate 24 in the plasma confinement electrode 20 and these two diffusion plates are piled up, the configuration which forms the mono-silane gas (inert gas) 19 of two or more diffusion plates so that

the hole to pour, i.e., hole 9A, and hole 9B may not lap in plane view (it is not located on a straight line — as) is also possible.

[0037] Next, with reference to drawing 1 , drawing 2 , drawing 3 , and drawing 4 , the formation approach of the oxidation silicone film to substrate 3 front face by the remote plasma-CVD equipment by 1 operation gestalt of this invention is explained below. Within the CVD chamber in an evacuation condition (it has a predetermined pressure) Introduce oxygen gas 18 into the RF impression electrode 1, and this oxygen gas 18 is supplied in the direction of the plasma confinement electrode 20 from the inferior surface of tongue of the RF impression electrode 1 at homogeneity. Glow discharge is made to start from RF generator 13 by the RF supplied to the RF impression electrode 1 between the plasma confinement electrodes 20 which have a diffusion plate (the 1st gaseous diffusion plate 23 and the 2nd diffusion plate 24 which are shown in drawing 4).

[0038] The oxygen plasma 22 generated by this glow discharge is efficiently shut up between the RF impression electrode 1 and the plasma confinement electrode 20. The plasma consistency between the plasma confinement electrode 20 and a counterelectrode 2 (or substrate 3) has become about [105cm – 3–106cm –] three to the plasma consistency in the result 22, for example, the oxygen plasma, being about [1010cm –] three.

[0039] That is, although an electron, oxygen atom ion, oxygen molecular ion, an oxygen atom radical, an oxygen molecule radical, and an oxygen molecule exist in the oxygen plasma 22, it is shown that the electron and ion which invade out of the plasma are the amount of extent which can be disregarded. Therefore, what it reacts with the mono-silane gas 19 injected by the substrate processing field R besides the oxygen plasma 22, and is contributed to silicon oxide film membrane formation is an oxygen atom radical, an oxygen molecule radical, and an oxygen molecule that is not excited.

[0040] And an oxygen radical and the oxygen molecule 21 are diffused to the substrate processing field R through the radical passage hole 5, and the mono-silane gas 19 and the gaseous-phase chemical reaction which were injected from the inert gas nozzle 9 are caused. Of this gaseous-phase chemical reaction, silicon oxide precursors (membrane formation precursor), such as SiOx, SiOxHy, and SiHy, are formed, and when this formed silicon oxide precursor accumulates on substrate 3 front face, an oxidation silicone film is formed in substrate 3 front face.

[0041] The distance D of the plasma confinement electrode 20 and a substrate 3 (vertical distance) is set up here so that it may become 1500 or less (however, number exceeding "0") times of average free process λ of the oxygen (the oxygen radical and oxygen molecule 21) / mono-silane mixed gas in the substrate processing field R. Since it has controlled that a gaseous-phase chemical reaction progresses superfluously with this distance D, when oxidation silicone film precursors, such as SiOx, SiOxHy, and SiHy, carry out grain growth by the gaseous phase in the substrate processing field R, it does not grow up to be particle-like magnitude.

[0042] For example, what is necessary is just to set distance D of a plasma confinement electrode and a substrate to 90mm or less in the gas temperature of 300 degrees C, and chamber pressure 250mTorr, since average free process λ of oxygen / mono-silane mixed gas is about 60 micrometers. The leak current characteristic when using as the gate dielectric film of an MOS (metal, oxide-film, and semi-conductor) capacitor the oxidation silicone film which actually formed membranes as an example which formed the oxidation silicone film on condition that the substrate temperature of 300 degrees C, substrate processing field R pressure 250mTorr, oxygen flow rate 800sccm supplied to a plasma field through the RF impression electrode 1, and mono-silane quantity-of-gas-flow 5sccm supplied to the inert gas installation tubing 12 is shown in drawing 5 .

[0043] In drawing 5 , the leak current density value has changed a lot by the case where distance D of the plasma confinement electrode 20 and a substrate 3 is set to 300mm, and the case where it is made 60mm. That is, the leak current characteristic of the film which formed the distance D of the plasma confinement electrode 20 and a substrate 3 as 60mm has near, the electric insulating property [it is good and] which can be used as gate dielectric film and the interlayer insulation film of a thin film transistor, and pressure-proofing in the current characteristic of the silicon thermal oxidation film.

[0044] On the other hand, big leakage current is flowing from the low electric-field field, the leak current characteristic of the film which formed the distance D of the plasma confinement electrode 20 and a substrate 3 as 300mm has an electric insulating property and low pressure-proofing to gate dielectric film and the interlayer insulation film of a thin film transistor, and they cannot use it for them.

[0045] In the experiment conditions mentioned above, average free process λ of the oxygen / mono-silane mixed gas in the substrate processing field R is about 60 micrometers. At this time, it corresponds by about 5000 times the above-mentioned average free process λ the distance D of an electric insulating property and the plasma confinement electrode 20 with lower pressure-proofing, and a substrate 3, i.e., 300mm.

[0046] On the other hand, it corresponds by about 1000 times the above-mentioned average free process λ the distance D of an electric insulating property and the plasma confinement electrode 20 with lower pressure-proofing, and a substrate 3, i.e., 60mm. If the distance D of the plasma confinement electrode 20 and a substrate 3 is 5000 times as large as the above-mentioned average free process λ , the gaseous-phase chemical reaction of an oxygen radical and the oxygen molecule 21, and mono-silane gas 19 will progress too much, the particle which carried out grain growth in the gaseous phase in the substrate processing field R will accumulate on substrate 3 front face as film, and it will be guessed that the roughness and fineness film has been formed in substrate 3 front face.

[0047] On the other hand, if it is the distance D of the about 1000 times [of the above-mentioned average free process λ] plasma confinement electrode 20, and a substrate 3, the gaseous-phase chemical reaction of an oxygen radical and the oxygen molecule 21, and mono-silane gas 19 will not progress too much, grain growth in a gaseous phase will be restricted, and it will be guessed that a particle-like oxidation silicone film precursor does not accumulate as film in substrate 3 front face.

[0048] Moreover, as mentioned above, since the plasma consistency between the plasma confinement electrode 20 and a counterelectrode 2 is very low, compared with the usual parallel monotonous plasma CVD, the plasma damage to a substrate 3 is stopped very low.

[0049] To the case on the front face of silicon in which the front face of a substrate 3 forms an MOS interface, this effectiveness When it appears notably and SiO₂ film is formed on a single crystal silicon substrate by the usual parallel monotonous plasma CVD When an oxidation silicone film is formed by parallel monotonous remote plasma CVD to the MOS interface-state-density consistency being 10¹¹-10¹²cm⁻²eV⁻¹ near a mid gap, it becomes an about [-10¹⁰cm⁻²eV⁻¹] low interface-state-density consistency.

[0050] As mentioned above, although 1 operation gestalt of this invention has been explained in full detail with reference to a drawing, a concrete configuration is not restricted to this operation gestalt, and even if the design change of the range which does not deviate from the summary of this invention etc. occurs, it is included in this invention. For example, the parallel monotonous remote plasma CVD by the 2nd operation gestalt is explained using drawing 6. Drawing 6 is the conceptual diagram showing the cross section of the configuration of parallel monotonous mold remote plasma-CVD equipment. About the same configuration as the conventional example and 1 operation gestalt, the same sign is attached and explanation of this configuration is omitted.

[0051] In this drawing, the parallel monotonous mold remote plasma-CVD equipment of drawing 6 differing from the parallel monotonous remote plasma-CVD equipment of drawing 1 is that the gas supply plate 29 which the inert gas installation tubing 12 is connected, introduces inert gas (mono-silane gas 19) into it, equalizes gas concentration with the gaseous diffusion plate formed in the interior, and is injected to a substrate side does not have the function of plasma confinement.

[0052] For this reason, that aperture is arbitrary if homogeneity injection of a radical 4 is possible for the radical passage hole 5 of the gas supply plate 29 which has a diffusion plate. Moreover, it is also possible to use it in the state of electric suspension, without grounding electrically. That is, although the gas supply plate 29 of the configuration itself is the same as that of the plasma confinement electrode 20 in 1 operation gestalt, the apertures of the point and radical passage hole which are not grounded differ.

[0053] In addition, this gas supply plate 29 is located between the plasma confinement electrode 8 and a counterelectrode 2, and it is set up so that the distance F of the gas supply plate 29 and a substrate 3 may become 1500 or less (however, number exceeding "0") times of average free process λ of the oxygen (the oxygen radical and oxygen molecule 21) / mono-silane mixed gas in the substrate processing field R.

[0054] Except the above, it has the structure where the plasma confinement electrode 20 which has the gas supply plate 29 which has a diffusion plate in the 2nd operation gestalt, and a diffusion plate in 1 operation gestalt is the same. Moreover, the view about the relation of distribution of the hole which passes the radical passage hole and inert gas in the structure of the gaseous diffusion plate in the gas supply plate 29 and the number of gaseous diffusion plates, and a gaseous diffusion plate etc. is the same as that of the gaseous diffusion plate (the 1st gaseous diffusion plate and 2nd gaseous diffusion plate) formed in the plasma confinement electrode 20 in 1 operation gestalt.

[0055] Moreover, it is the same as that of the view about the distance D of the plasma confinement electrode 20 and substrate 3 in 1 operation gestalt, an oxygen radical and the oxygen molecule 21, and the gaseous-phase chemical reaction of mono-silane gas 19 do not progress too much, grain growth in a gaseous phase is restricted, and particle does not deposit the view over the distance F of the gas supply plate 29 and a substrate 3 on the front face of a substrate 3 as film, either.

[0056] In the above 1 operation gestalt and the 2nd operation gestalt, although the silicon oxide film formation using a mono silane and oxygen was mentioned as the example and this invention was explained, liquid Si raw materials, such as high order silanes, such as a disilane, and TEOS (Tetraethoxysilane), etc. are sufficient instead of a mono silane, and nitrous oxide, nitrogen oxide, etc. may be used instead of oxygen.

[0057] Moreover, although explained by the remote plasma-CVD equipment in 1 operation gestalt and the 2nd operation gestalt which were mentioned above mentioning oxidation silicone film formation as an example Even if it uses the silicon nitride film formation by the reaction of a mono silane and ammonia etc. for the plasma-CVD membrane formation accompanied by the gaseous-phase chemical reaction of other ingredient systems, the same effectiveness as the film generated with 1 operation gestalt and the 2nd operation gestalt can be acquired to the generated film.

[0058] Furthermore, although the example using parallel monotonous remote plasma-CVD equipment was given in the gestalt of the above operation, this invention will be applied, even if it is equipments of what kind of gestalt, such as plasma-CVD equipment using the microwave plasma, the electron cyclotron resonance plasma, inductively coupled plasma, and the helicon wave plasma, if it is plasma-CVD equipment with which two or more holes were prepared between the plasma production field and the substrate processing field R and which has a plasma confinement electrode for plasma separation.

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is the side-face schematic diagram of the parallel monotonous remote plasma-CVD equipment in the gestalt of operation of the 1st of this invention.

[Drawing 2] It is the cross-section schematic diagram of an electrode in the slight plasma closing depth in the 1st operation gestalt of this invention which has a diffusion plate.

[Drawing 3] It is the flat-surface schematic diagram of the up plate of an electrode, and a lower plate in the slight plasma closing depth in the gestalt of operation of the 1st of this invention which has a diffusion plate.

[Drawing 4] It is the flat-surface schematic diagram of the diffusion plate in the gestalt of operation of the 1st of this invention.

[Drawing 5] It is drawing having shown the leak current characteristic of the deposited oxidation silicone film.

[Drawing 6] It is the side-face schematic diagram of the parallel monotonous remote plasma-CVD equipment in the gestalt of operation of the 2nd of this invention.

[Drawing 7] It is the side-face schematic diagram of the parallel monotonous remote plasma-CVD equipment in the conventional example.

[Drawing 8] It is the cross-section schematic diagram of the plasma confinement electrode of the hollow structure in the conventional example.

[Drawing 9] It is the flat-surface schematic diagram of the plasma confinement electrode of the hollow structure in the conventional example.

[Drawing 10] In the conventional example, it is the side-face schematic diagram of the parallel monotonous remote plasma-CVD equipment which showed how to supply inert gas from the vacuum chamber exterior to the plasma confinement electrode of hollow structure.

[Drawing 11] In the plasma confinement electrode of the hollow structure in the conventional example, it is the cross-section schematic diagram of the plasma confinement electrode in which the situation of injection of gas is shown.

[Description of Notations]

1 RF Impression Electrode

2 Counterelectrode

3 Substrate

4 Radical

5 Radical Passage Hole

6 Plasma

7 Chamber Wall

8 Plasma Confinement Electrode

9 Inert Gas Nozzle

10 Inert Gas

11 Inert Gas for Plasma Decomposition

12 Inert Gas Installation Tubing

13 RF Generator

16 Evacuation

18 Oxygen Gas

19 Mono-Silane Gas

20 Plasma Confinement Electrode Which Has Diffusion Plate (Plasma Confinement Electrode)

- 21 Oxygen Radical and Oxygen Molecule
- 22 Oxygen Plasma
- 23 1st Gaseous Diffusion Plate
- 24 2nd Gaseous Diffusion Plate
- 26 Plasma Confinement Electrode Up Plate
- 27 Plasma Confinement Electrode Lower Plate
- 29 Gas Supply Plate Which Has Diffusion Plate

[Translation done.]

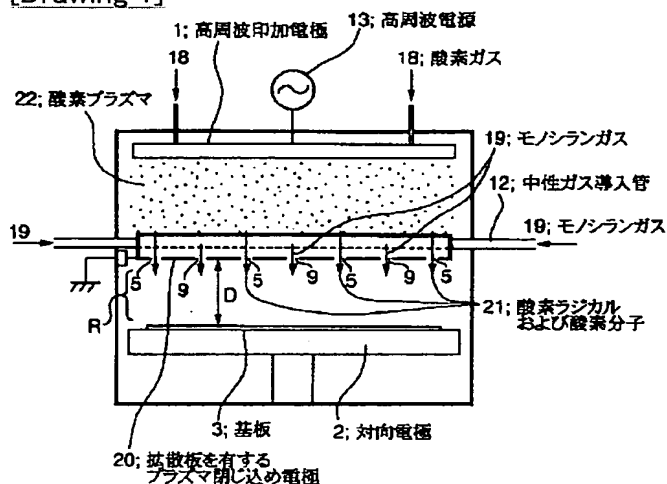
* NOTICES *

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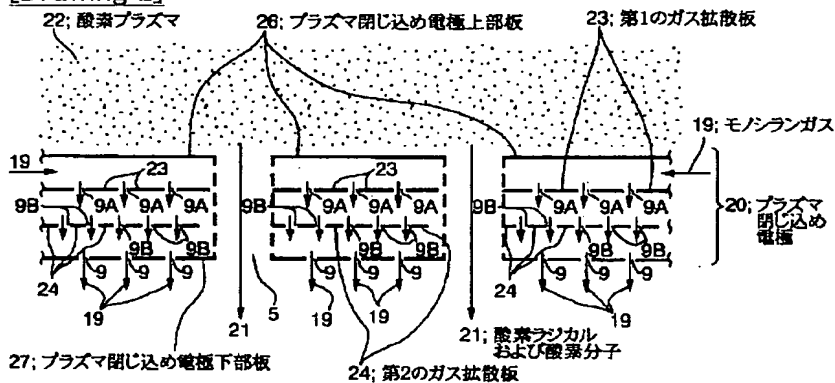
- 1.This document has been translated by computer. So the translation may not reflect the original precisely.
- 2.**** shows the word which can not be translated.
- 3.In the drawings, any words are not translated.

DRAWINGS

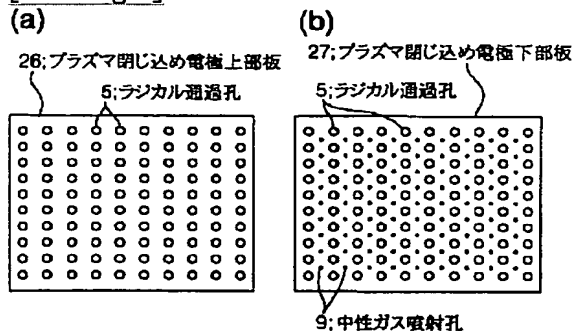
[Drawing 1]



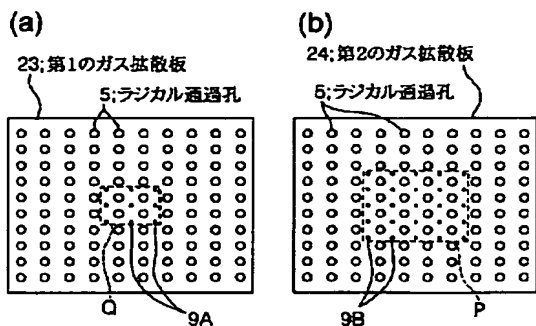
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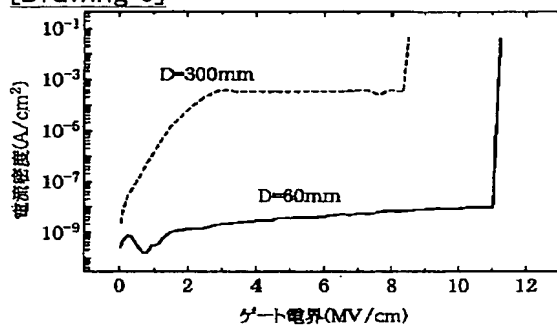
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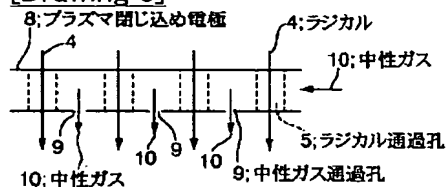
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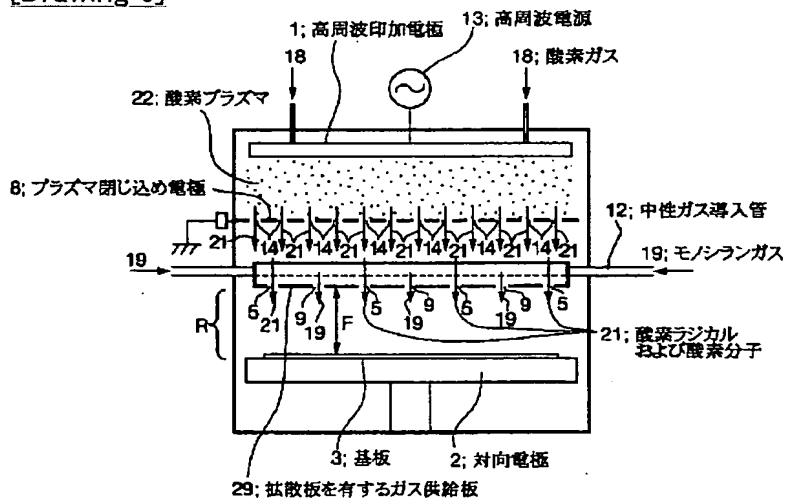
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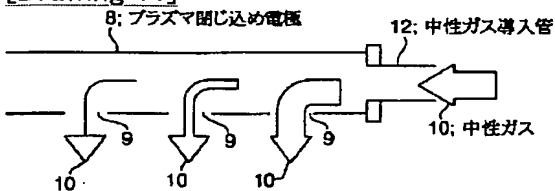
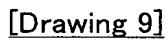
[Drawing 8]



[Drawing 6]



[Drawing 7]



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